National Research Council Canada

Conseil national de recherches Canada

ENSEIGNEMENT DE LA TOXICOLOGIE AU CANADA

Juillet, 1990

TOXICOLOGY EDUCATION IN CANADA

July 1990

NRCC No. 28358

CNRC N° 28358

ASSOCIATE COMMITTEE ON TOXICOLOGY

COMITÉ ASSOCIÉ DE TOXICOLOGIE

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PREFACE

This document contains detailed descriptions of toxicology programs available at Canadian Universities. These descriptions were prepared from information supplied by the Universities and have only been edited to attain a common format. Information on programs is given in the language of instruction and these have not been translated.

The information in this document was current in March of 1990 and, while every effort was made to be inclusive, programs of instruction may have been changed and students and other interested persons should contact the University for the most recent description of the program.

The inclusion of a program description in this guide does not constitute an endorsement of the program by ACTOX or the NRC, nor does the omission of a program or information on a program constitute a lack of endorsement.

It is our hope that this document will be updated on a regular basis and that it will be expanded to include more information. The Education Subcommittee of ACTOX would appreciate any comments and suggestions that you may have.

K.R. Solomon, Chair, Education Subcommittee.

PRÉFACE

Ce document contient des descriptions détaillées des programmes de Toxicologie offerts par les universités canadiennes. Ces descriptions ont été tirées de l'information fournie par les universités, et seules des modifications visant à assurer l'uniformité de la présentation y ont été apportées. L'information sur les programmes est fournie dans la même langue que les cours, les programmes n'ayant été traduits.

L'information contenue dans ce document a été compilée au mois de mars 1990, et bien que l'on ait pris tout le soin nécessaire pour que l'information soit complète, les programmes de cours peuvent changer avec le temps, et l'on recommande aux étudiants ou aux personnes intéressées de s'adresser aux universités pour obtenir une description plus récente des programmes offerts.

L'inclusion dans ce recueil de descriptions de programmes, ou l'omission de programmes ou des renseignements s'y rapportant, ne reflètent aucunement l'opinion du Comité associé de toxicologie ni celle du CNRC à l'égard de ces programmes.

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1 INTRODUCTION

In response to enhanced scientific and public concern with the prevalence of potentially toxic natural and man-made chemicals in our environment, and the subsequent demand for trained toxicologists, a number of universities in Canada have established educational programs which place emphasis on toxicology. While these actions are more than welcome, it appears that details of many programs are largely unknown, except for those individuals who are directly involved with these programs. Students and prospective employers of graduates, however, are somewhat bewildered by the variety of offerings, and often do not know what training programs are actually available.

To fill this void, ACTOX undertook to collate the information contained in this report. The assembled information should be useful not only to those teaching and administering such programs, but also to students considering toxicology as a career.

As will be seen in the following sections, there is an array of options, and it is probably best to list these options in a summary fashion.

(1) Pharmacology departments have, by tradition, offered training in toxicology, leading to M.Sc. or Ph.D. degrees. Only lately, however, have some of these departments begun to call themselves "Pharmacology/Toxicology" departments.

(2) Recognizing the need for more broadly trained toxicologists (i.e., encompassing the field of ecotoxicology) in addition to the more traditional fields, some universities have created multidisciplinary programs which lead to a M.Sc. or Ph.D. degree in toxicology *per se*.

(3) Some universities also have established Post-graduate Diploma programs in response to needs. The Post-graduate Diploma programs offer course work only. They also are designed to allow an employed individual who is already the holder of a post-graduate degree to upgrade his/her knowledge in toxicology.

(4) Finally, some universities have chosen to emphasize undergraduate training in toxicology.

1 INTRODUCTION

La présence dans l'environnement de produits chimiques naturels et synthétiques potentiellement toxiques suscite des préoccupations croissantes tant dans le secteur scientifique que chez le grand public. Compte tenu de ces préoccupations et de la demande accrue de toxicologues hautement qualifiés qui découle de cette situation, un certain nombre d'universités canadiennes ont mis en place des programmes de formation mettant l'accent sur la toxicologie. Bien que ces mesures soient très encourageantes, il semblerait qu'en dehors des scientifiques qui participent à ces programmes, peu de personnes en connaissent l'existence. Les étudiants et les employeurs potentiels de diplômés sont souvent déroutés par la variété des cours offerts dans ce domaine, et ils sont généralement mal renseignés sur les programmes de formation actuellement disponibles.

Pour combler cette lacune, le Comité associé de toxicologie a décidé de colliger l'information contenue dans ce rapport. Elle devrait s'avérer utile non seulement pour les enseignants et les administrateurs des programmes en question, mais également pour les étudiants qui envisagent de faire carrière dans le domaine de la toxicologie.

Comme on le verra dans les sections suivantes, les orientations offertes sont variées, et il a été jugé préférable de les énumérer sous forme de résumé.

(1) Les départements de pharmacologie ont toujours offert des cours de formation en toxicologie conduisant à une maîtrise ou à un doctorat. Cependant, ce n'est que depuis tout récemment qu'ils se sont donnés le nom de départements de «pharmacologie/toxicologie».

(2) Reconnaissant la nécessité de former des toxicologues possédant des connaissances plus étendues dans des domaines tels que l'écotoxicologie, en plus de leur spécialisation traditionnelle, quelques universités ont mis en place des programmes pluridisciplinaires conduisant à une maîtrise ou à un doctorat en toxicologie proprement dite.

(3) Quelques universités ont également mis en place des programmes de diplômes de niveau 2e cycle. Ces programmes n'offrent que des cours. Ils permettent aux personnes employées et déjà titulaires d'un diplôme du 2e ou 3e cycle de parfaire leurs connaissances dans le domaine de la toxicologie.

(4) Finalement, quelques universités ont choisi d'intensifier l'enseignement de la toxicologie au niveau du 1er cycle.

2 CONTENU D'UN PROGRAMME DE FORMATION EN TOXICOLOGIE

La Société de toxicologie du Canada (STC) a préparé en 1989 un exposé de principes sur la formation en toxicologie. Ce document est reproduit ici avec la permission de la STC.

UN PROGRAMME DE FORMATION EN TOXICOLOGIE: ÉLÉMENTS ET CONTENU

APERÇU GÉNÉRAL

La TOXICOLOGIE est l'étude qualitative et quantitative des effets délétères des agents chimiques et physiques sur les organismes vivants, tels qu'ils se manifestent par des modifications touchant la structure ou la réponse (fonction) de ces organismes (W.J. Hayes, Jr., 1975). La toxicologie est un domaine hautement intégré des sciences biomédicales et elle s'intéresse ultimement à la pathobiologie des maladies provoquées par des agents d'origine naturelle ou anthropique. La toxicologie fait appel à toute la gamme des techniques d'investigation utilisées dans les sciences biomédicales (fig. 1). Il s'agit néanmoins d'une discipline distincte dont les objectifs sont spécifiques. Du point de vue de l'enseignement, la toxicologie fait intervenir, en raison de sa base de connaissances étendue, presque toutes les disciplines scientifiques enseignées dans une université traditionnelle, ce qui a pour conséquence qu'aucun département ne peut, à lui seul, satisfaire tous les besoins en matière de formation et de recherche.

La tâche du toxicologue consiste à caractériser, à mesurer, à interpréter et à prévoir les effets des agents sur les systèmes vivants. La formation en recherche du toxicologue doit être fondée sur un domaine de spécialité, mais tous les étudiants en formation devraient être exposés à une gamme étendue et représentative des différentes disciplines toxicologiques pour qu'ils puissent apprécier les dimensions descriptive, mécanistique, prédictive et évaluative de la toxicologie et qu'ils puissent se familiariser avec ces dernières. Plus que dans la plupart des autres champs scientifiques, la souplesse devrait être une préoccupation primordiale dans le programme de formation en toxicologie, même s'il est impossible qu'une même personne puisse englober, dans sa pratique, toutes les facettes de cette discipline. Une formation fondée sur une base scientifique étendue permettra aux toxicologues de développer leurs capacités d'autoperfectionnement.

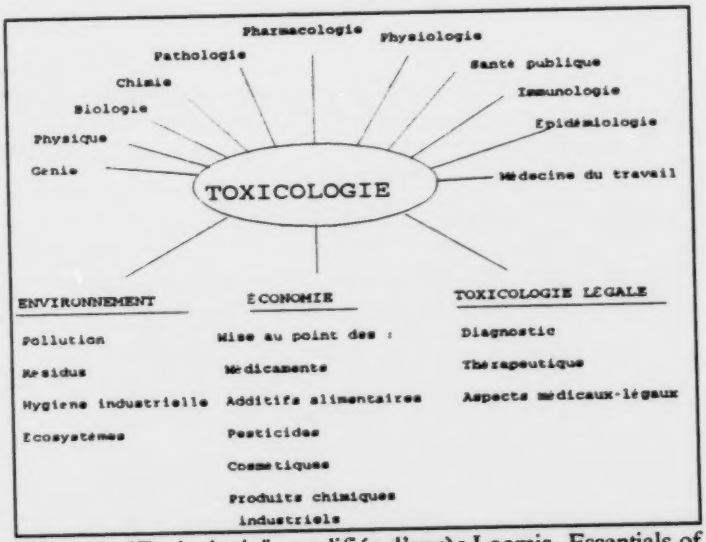

Figure 1 "Toxicologie", modifiée d'après Loomis, Essentials of Toxicology, troisième édition (1978)

La nature interdisciplinaire de la toxicologie pose, du point de vue du programme de formation, des difficultés uniques que l'on ne rencontre pas dans le cas des disciplines scientifiques dont l'objet est plus restreint. La toxicologie exige une formation dans une variété d'autres disciplines scientifiques et une formation avancée dans une ou plusieurs des techniques de recherche établies ou nouvelles qui

s'appliquent à la recherche en toxicologie. Cela facilitera l'application de l'expertise acquise à l'université (études de premier cycle et études supérieures) à des problèmes toxicologiques multidisciplinaires complexes et permettra aux toxicologues d'être compétents dans différents domaines.

Dans le contexte du présent exposé de principes, le Comité d'éducation de la STC ne s'est intéressé qu'aux études supérieures, délaissant la formation au niveau du premier cycle. Le Comité est d'avis que les étudiants qui s'inscrivent au programme d'études supérieures en toxicologie devraient avoir reçu une formation dans les sciences fondamentales durant le premier cycle.

Le but du présent exposé de principes se limite à présenter l'approche conceptuelle générale face à la formation supérieure en toxicologie, l'élaboration du contenu spécifique des cours étant laissée à la discrétion des personnes responsables des programmes en question.

OBJECTIFS

L'objectif premier de tout programme d'études supérieures est de fournir du personnel qualifié pour répondre aux besoins en main-d'oeuvre dans différents domaines de la science. En toxicologie, le meilleur moyen d'atteindre cet objectif repose sur une approche fondée sur une équipe multidisciplinaire et intégrée. Par conséquent, les étudiants doivent recevoir une formation qui leur permette d'acquérir des compétences particulières nécessaires au travail en équipe visant à résoudre des problèmes toxicologiques.

L'objectif plus large poursuivi dans le cadre d'un programme de formation supérieure devrait être axé davantage sur le développement de la pensée toxicologique, plutôt que sur la formation technique très polyvalente; il est en effet illusoire et contre-productif de s'attendre à ce qu'un étudiant acquière des connaissances suffisamment étendues et approfondies dans toutes les disciplines de la toxicologie pour lui permettre de faire face efficacement à une grande variété de problèmes toxicologiques. Le grand défi à relever, lorsqu'on veut mettre sur pied un programme de formation supérieure en toxicologie, consiste à organiser les programmes existants sous une forme intégrée de manière que les étudiants puissent comprendre les rôles des diverses disciplines intervenant dans la solution de problèmes toxicologiques.

La formation en toxicologie doit être adaptée aux besoins de chacun des étudiants selon qu'il oriente sa carrière vers la recherche ou vers la pratique. Il peut en découler certaines difficultés si les candidats aux programmes de formation n'ont pas une idée très claire des différents choix de carrière qui correspondent à leur formation de premier cycle; il faudrait donc que les candidats aient eu une certaine exposition aux différentes disciplines de la toxicologie, par exemple dans le cadre d'un cours d'introduction de premier cycle.

ÉLABORATION DU COURS

Les expériences vécues au cours des deux dernières décennies aux États-Unis peuvent être très révélatrices. En réponse à l'adoption de la Loi sur les substances toxiques au début des années 70 et aux inquiétudes face à une pénurie estimée de toxicologues formés, un grand nombre de programmes de formation plutôt limitée ont été institués par les universités et financés par le gouvernement fédéral américain. Un petit nombre de programmes sont parvenus à assurer la formation étendue et approfondie nécessaire; ils ont survécu et continuent à produire d'excellents toxicologues. D'autres programmes, axés principalement sur les cours, ont produit des candidats qui ont été jugés inacceptables par les laboratoires

industriels étant donné que ces candidats n'avaient pas les compétences conceptuelles et techniques nécessaires à la planification des études de toxicité aiguë, subaiguë et chronique exigées par les organismes de réglementation. La plupart des programmes de formation de ce dernier type ont disparu ou ont été réorganisés parce que l'industrie, en tant qu'un des principaux employeurs de diplômés en toxicologie, exigeait des candidats formés dans les disciplines traditionnelles, mais ayant une formation postdoctorale (cours et recherche) en toxicologie. Seuls les quelques centres donnant une formation supérieure sur une base élargie ont été en mesure de répondre à ces demandes.

Avant d'être admis à un programme de formation en toxicologie, les étudiants devraient posséder des connaissances de base solides dans les disciplines suivantes : 1) chimie (inorganique, organique, physique), 2) sciences biologiques ou biomédicales (biologie, biochimie, physiologie, pharmacologie, etc.), 3) pathologie, et 4) biostatistique. Cette formation de base peut comprendre ou non des cours d'introduction en toxicologie. Étant donné les antécédents variables des étudiants, les conditions d'admission devraient être souples. Le contenu doit être structuré de façon à ce que les étudiants en formation soient parfaitement informés des divers éléments de la recherche toxicologique, parmi lesquels on retrouve:

a) les sources des produits toxiques
b) la caractérisation des produits toxiques
c) la distribution et le transport des agents depuis les sources jusqu'aux organismes et aux tissus cibles
d) la caractérisation des réponses des organismes et des tissus cibles
e) les mécanismes d'action des agents
f) le métabolisme, l'élimination et le devenir des agents dans les organismes cibles
g) les signes cliniques de toxicité
h) les stratégies thérapeutiques existantes pour atténuer et prévenir les effets des produits toxiques
i) l'intervention à l'échelle de la population - programmes de prévention, mesures de réglementation.

L'environnement qui convient le mieux à une formation sur une base la plus large possible est le milieu universitaire dans lequel toutes les disciplines participantes peuvent collaborer à la recherche scientifique portant sur des problèmes toxicologiques. Comme les milieux de ce genre sont peu nombreux à l'heure actuelle, leur développement doit être favorisé par l'utilisation du corps professoral existant et le financement de projets de recherche multidisciplinaires, peut-être même à l'échelle du campus, dans le cadre d'un "institut" d'études environnementales ou d'un "centre" ou d'un "groupe" de recherche en toxicologie. L'existence d'une expertise et de fonds de recherche aurait pour effet de favoriser le développement d'une formation spécifique dans n'importe laquelle des disciplines participantes et fournirait l'éventail des cours requis au niveau des études supérieures et des programmes de séminaires ; on créerait ainsi un climat favorable à l'éclosion d'une aptitude à exercer un jugement critique, qualité essentielle à la recherche en toxicologie.

Des cours de base couvrant les dimensions descriptive, mécanistique et prédictive de la toxicologie doivent être exigés de tous les étudiants qui s'inscrivent dans un programme d'études supérieures, de manière que ces étudiants acquièrent les connaissances et habiletés suivantes :

I. Habiletés conceptuelles et connaissances de base :

a) principes de la toxicologie
b) fondements et méthodes de l'évaluation toxicologique

c) compréhension des mécanismes de l'action toxique des produits toxiques
d) circonstances d'utilisation et problèmes liés à l'utilisation de diverses classes de produits chimiques (p. ex., médicaments, produits chimiques domestiques, toxiques environnementaux, toxiques en milieu de travail, toxiques reliés à l'alimentation et à l'agriculture)
e) sensibilisation aux principales questions d'ordre sanitaire, social, environnemental et économique reliées aux grandes classes de produits chimiques à l'origine des problèmes de toxicité.

II. Habiletés du point de vue des techniques toxicologiques, de l'interprétation des données et de la communication :

a) évaluation des propriétés toxiques des produits chimiques
b) reconnaissance et évaluation des problèmes causés par l'exposition à divers agents
c) utilisation des sources de données toxicologiques
d) élaboration et application de solutions à des problèmes toxicologiques
e) évaluation de la probabilité d'apparition de la toxicité (risque)
f) communication des concepts (a à d ci-dessus) et de l'information à d'autres personnes parmi lesquelles se trouvent des scientifiques, des représentants du gouvernement, de l'industrie, des médias d'information, des autorités de réglementation, sans oublier le grand public.

III. Habiletés du point de vue de la sensibilité, du jugement critique et de l'éducation permanente :

a) compréhension de l'approche multidisciplinaire nécessaire à l'investigation et à l'intervention en toxicologie
b) flexibilité et réceptivité face à l'intégration des nouvelles connaissances et technologies et, par dessous tout, capacité de s'auto-évaluer pour déceler ses faiblesses et les corriger
c) sensibilité aux influences d'ordre politique, social, environnemental et économique sur les problèmes toxicologiques et sur l'acceptation (ou l'évitement) du risque.

Les connaissances de base peuvent être transmises par l'intermédiaire de cours formels et organisés, couvrant les dimensions descriptive, mécanistique et prédictive de la toxicologie. Les habiletés et les attitudes devraient être développées par la solution de problèmes, en ayant recours le plus possible à une expertise qui vient de l'extérieur du milieu universitaire, à savoir des spécialistes de la réglementation, des représentants de l'industrie, des cliniciens, etc. On pourrait y parvenir soit par la recherche toxicologique appliquée ou des cours spécifiques, les étudiants ayant ainsi l'occasion de discuter et d'évaluer des problèmes toxicologiques réels et de débattre des avantages et des inconvénients des diverses solutions proposées, en se fondant sur les connaissances acquises à partir des cours ou sur l'expérience propre à chacun des étudiants. Cette façon de procéder aurait pour effet d'accroître les habiletés des étudiants à communiquer.

Des cours additionnels destinés à élargir les horizons des étudiants dans des disciplines spécifiques connexes, dans des domaines d'applications spécialisées de la toxicologie (toxicologie environnementale, aquatique, légale, tératologie, immunotoxicologie, cancérogenèse, etc.) ou dans les sciences biomédicales (biochimie, pharmacologie, physiologie, nutrition, pathologie, radioprotection, biostatistique, etc.) devraient être offerts pour accroître les connaissances essentielles à un toxicologue.

Il n'entre pas dans le cadre du présent document de décrire les meilleures méthodes pour acquérir les diverses dimensions de la formation d'un étudiant diplômé. Dans la fig. 2, on décrit la provenance des candidats et leur formation au moment de leur admission dans les programmes de formation en

toxicologie. On y indique les cours de base que tous les étudiants devraient suivre pour maîtriser les aspects conceptuels de la toxicologie. On y indique également l'éventail des cours additionels avancés en toxicologie (cours d'un trimestre) et dans d'autres disciplines (cours de un et de deux trimestres) auxquels des étudiants ayant des antécédents différents peuvent s'inscrire pour poursuivre des objectifs de carrière spécifiques. Un équilibre doit être trouvé entre la charge de cours et la recherche, dans la mesure où le temps et la charge de travail le permettent. On s'attend à ce que les superviseurs de recherche des étudiants et les comités consultatifs de professeurs guident les étudiants dans le choix des cours appropriés.

RECHERCHE

La description précise de la composante recherche d'un programme de formation au niveau supérieur sort du cadre du présent document. Le projet de recherche doit porter sur un problème spécifique à l'intérieur d'un domaine de la recherche toxicologique. Cette recherche peut se faire dans le cadre plus réduit d'une discipline particulière ou peut être de nature interdisciplinaire. Elle devrait être complétée par le programme de cours.

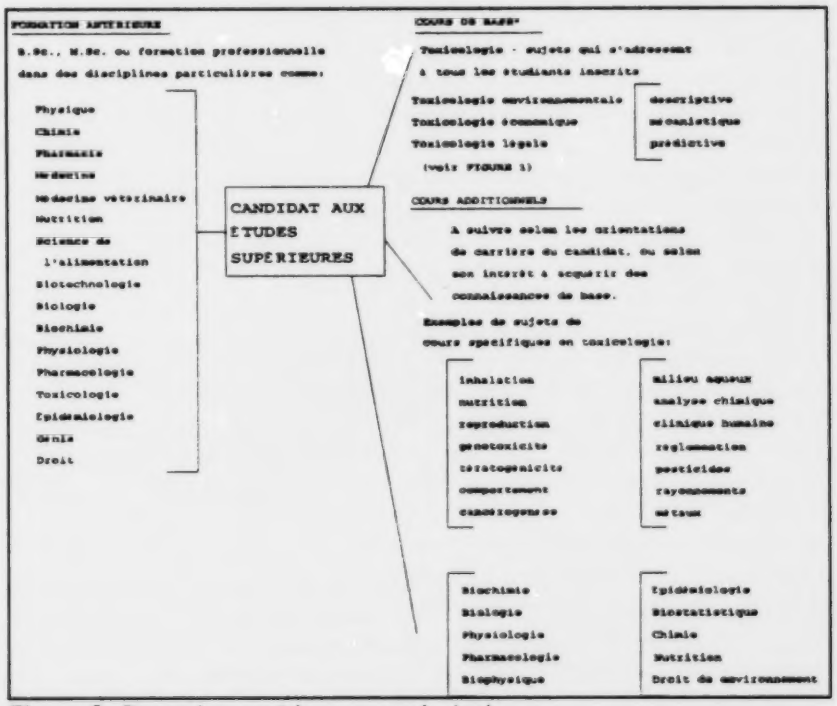

Figure 2 Formation supérieure en toxicologie

Rien ne peut se substituer à la composante recherche pour obtenir l'esprit d'analyse nécessaire pour maîtriser les dimensions évaluatives et prédictives de la toxicologie. Que l'étudiant choisisse de poursuivre sa carrière dans le domaine de la recherche ou qu'il opte pour un autre genre d'activité (évaluation, réglementation, communication, etc.), les processus intellectuels développés au cours de la composante recherche du programme de formation resteront applicables à tous les aspects de la toxicologie.

* On prévoit que, selon la provenance de l'étudiant (médecine, biologie, droit, génie, etc.), le programme de cours maintiendra un intérêt à caractère disciplinaire et variera donc éeconsidérablement d'un étudiant à l'autre.

2 COMPONENTS AND CONTENTS OF A TRAINING PROGRAM IN TOXICOLOGY

The Society of Toxicology of Canada (STC) prepared, in 1989, a position paper on Training in Toxicology. The document is reproduced, below, with the permission of STC.

A TRAINING PROGRAM IN TOXICOLOGY: COMPONENTS AND CONTENTS

OVERVIEW

TOXICOLOGY is the qualitative and quantitative study of the injurious effects of chemical and physical agents or energy on living organisms as observed by alterations in structure or response (function) (W.J. Hayes, Jr., 1975). Toxicology is a highly integrated field of biomedical sciences and is ultimately concerned with pathobiology of disease induced by agents of natural or anthropogenic origin. Toxicology draws from the full range of investigative technologies employed in biomedical sciences (Figure 3). It is, nonetheless, a separate and distinct discipline with unique goals. As a result of its broad base, academic toxicology involves almost all scientific branches taught at a conventional university with the consequence that no one department can satisfy the requirements for training and research.

Toxicologists characterize, measure, interpret and predict the effects of agents or energy on living systems. The research training for each individual would be based on a specialty area but each trainee should be exposed to a broad, cross-section of toxicological disciplines to give an appreciation of and familiarity with the descriptive, mechanistic, predictive and evaluative dimensions of toxicology. More than in most other scientific fields, versatility should be of prime consideration in a toxicological training program even though the practice of toxicology by any one individual cannot possibly encompass all facets of the discipline. A broad-based training will assist in the development of self-training abilities of toxicologists.

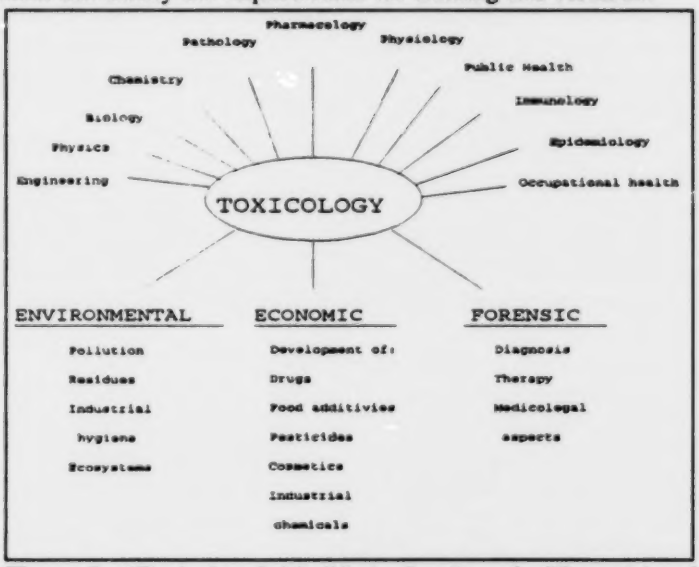

Figure 3 "Toxicology" Modified after Loomis "Essentials of Toxicology." Third Edition (1978)

The interdisciplinary nature of toxicology poses some unique problems in a training program, problems not encountered in the more restricted scientific disciplines. Toxicology will require individuals trained in a variety of other scientific disciplines, with advanced training in one or more of the established or new research technologies appropriate for toxicological research. This will facilitate the application of acquired undergraduate and graduate expertise to complex multidisciplinary toxicological problems and enable toxicologists to be competent in different areas.

In the context of this position paper, the STC Education Committee considered only graduate

training and did not deal with undergraduate training. It was the opinion of the committee that students entering a graduate program in toxicology should be well trained in the basic sciences.

The purpose of this position paper is to present only the broad conceptual approach to graduate training in toxicology, leaving the development of specific course content in the hands of those involved in the program(s).

GOALS

The primary goal of any graduate program is the production of trained personnel to meet the manpower needs in various areas of a scientific discipline. In toxicology, this goal can be best met by an integrated, multidisciplinary team approach. Accordingly, people should be trained with particular skills required to participate in the team's needs to solve toxicological problems.

The broader goal in a graduate training program should emphasize conceptual development rather than the multifaceted technological training since it is impractical and counterproductive to expect that a trainee will acquire sufficient breadth and depth of knowledge in all component disciplines to deal effectively with a variety of toxicological problems. The challenge of a graduate training program in toxicology is to organize existing programs into an integrated format wherein the trainees obtain an understanding of the roles of the various participating disciplines in the solution of toxicological problems.

Training in toxicology must be tailored to the individual student's needs in consideration of career choices as a researcher or as a practitioner. This may present problems in that applicants to training programs may have no clear view of what career options fit their undergraduate training unless there has been some exposure to the scope of toxicology, such as in an introductory undergraduate course.

COURSE DEVELOPMENT

The experiences of the past two decades in the U.S.A. may be instructive. In response to the toxic substances legislation in the early 1970s and concerns about an estimated shortfall in trained toxicologists, a large number of rather limited training programs were initiated by universities and funded by federal government agencies. A few of the programs gave the depth and breadth of training required, have survived and are still producing excellent graduate "products". Other programs, primarily course oriented, produced a trainee who was unacceptable to industrial laboratories because these graduates were inadequate in the conceptual and technical skills required in the design of acute, subacute and chronic toxicity studies required by regulatory agencies. Most of the latter type of training programs have disappeared or have been reorganized because industrial organizations, as major employers of toxicology graduates, require individuals trained in the traditional disciplines but with postdoctoral training (courses and research) in toxicology. Only the few centres giving a broad-based graduate training have been capable of responding to these demands.

Before entering a toxicology training program, students should possess a sound basic knowledge of (1) chemistry (inorganic, organic, physical); (2) biological or biomedical sciences (biology, biochemistry, physiology, pharmacology, etc.); (3) pathobiology of disease; and (4) biostatistics. This background may or may not include introductory courses in toxicology. Given the variable background of students, the admission requirements should be flexible, depending upon the opportunities within the proposed program to ensure that the trainees are made fully aware of the various components of toxicological research, including

a) sources of toxicants

b) characterization of the toxicants
c) distribution and transport of the agents from sources to the target organism(s) and tissues
d) characterization of the responses of the target organisms and tissues
e) mechanisms of action of the agents
f) metabolism, elimination and fate of agents in target organisms
g) clinical signs of toxicity
h) therapeutic strategies for alleviation of toxic responses and their prevention
i) intervention at the population level - prevention programs, regulatory measures

The most suitable environment for training on the broadest possible base is an academic environment in which all of the component disciplines can co-operate in scientific research on toxicological problems. Since few such situations exist at present, their development must be fostered by the utilization of existing faculty and the funding of multidisciplinary research projects, possibly within the framework of a campus-wide "institute" of environmental studies or a toxicological research "centre" or "group". The availability of expertise and research funding would promote the development of specific disciplinary training in any of the component disciplines and would provide the breadth of graduate courses, seminar programs and critical judgement essential for the broad-based conceptual approach to toxicological research.

Core courses in the descriptive, mechanistic and predictive dimensions of toxicology must be required of all students enroled in a graduate program in order that all trainees acquire the following

I. Conceptual Skills and Basic Knowledge

a) principles of toxicology
b) rationale and methods of toxicological evaluation
c) understanding of the mechanisms of toxic action(s) for individual toxicants
d) circumstances and problems associated with the use of various classes of chemicals (i.e. drugs, household chemicals, environmental, occupational, food and agricultural toxicants)
e) awareness of the main health, social, environmental and economic issues pertaining to major classes of chemicals causing toxic problems

II. Technical, Interpretive and Communication Skills

a) evaluation of the toxic properties of chemicals
b) recognition and measurement of problems caused by exposure to various agents
c) use of toxicology data sources
d) development and application of solutions to toxicological problems
e) assessment of the probability of occurrence of toxicity (risk)
f) communication of concepts (a-d above) and information to others, including scientists, government, industry, media, regulatory authorities and the general public.

III. Awareness, Judgement and Continuing Education Skills

a) understanding of the multidisciplinary approach to investigation and intervention in toxicology
b) flexibility and receptiveness in integrating new knowledge and technologies and, above all, the capacity to self evaluate one's areas of weakness and to correct these
c) awareness of the political, societal, environmental and economic influences on toxicological

problems and risk acceptance (or avoidance)

Basic knowledge can be imparted by organized, didactic courses covering the descriptive, mechanistic and predictive dimensions of toxicology. Skills and attitudes should be developed by problem solving using, as much as is possible, the expertise of non-academicians, regulators, industry, clinicians, etc. This could be achieved either in applied toxicological research or specific courses, the students having the opportunity to debate and evaluate real-life toxicological problems and to debate the merits of various proposed solutions, drawing upon the knowledge acquired from the coursework of from the unique experience(s) of each trainee. This format would enhance the communication skills of the trainees.

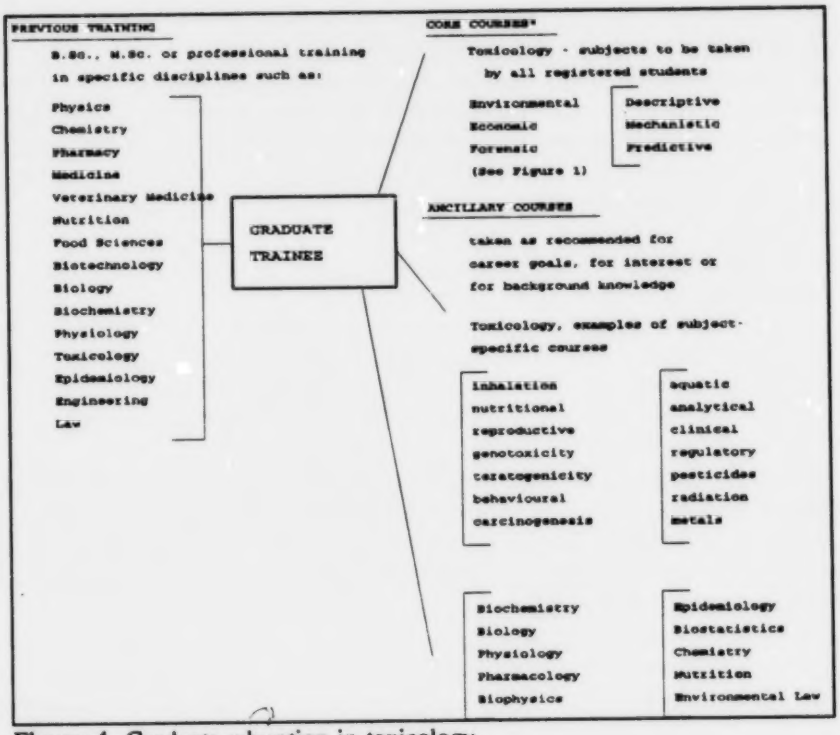

Figure 4 Graduate education in toxicology

Ancillary courses to broaden the horizons of the trainee within specific disciplines, within the broad aspect of toxicology (environmental, aquatic, forensic, teratology, immunotoxicology, carcinogenesis, etc.) or within the larger aspect of biomedical science (biochemistry, pharmacology, physiology, nutrition, pathology, radiation physics, biostatistics, etc.) should be available in order to enhance knowledge essential for a toxicologist.

* It is expected that, depending upon the "origins" of the training programme (medical school, biology, law, engineering, etc.), the course format will be discipline-oriented and will vary considerably

It is not the purpose of this paper to outline the best method of acquiring the dimensions of training of the graduate. The scheme shown in Figure 4 describes the source of the candidates and their training on entering toxicology training programs. It shows the core courses that all students should take in order to develop the conceptual aspects of toxicology. Shown also are the breadth of advanced, ancillary courses in toxicology (half year courses) as well as ancillary courses in the other disciplines (half and full year courses) that students with a variety of backgrounds may take to pursue specific career goals. A balance would have to be attained between coursework and research as time and effort allows. It is expected that the trainees' research supervisors and faculty advisor committees would guide students in the selection of appropriate courses.

RESEARCH

It is not the purpose of this paper to identify and describe the research component of a graduate training program. The research project should address a specific problem within the broad range of toxicological research. This research may be within a specific discipline or be of an interdisciplinary nature. It should be complemented by the course program.

There is no substitute to the research component of training to obtain the analytical frame of mind needed to master the evaluative and predictive dimensions of toxicology. Whether or not the trainee continues in research or embarks on a non-research career (evaluation, regulatory, communications, etc.), the thought processes developed during the research component of the training program will be applicable to all aspects of toxicology.

3 METHODOLOGY USED

As a preliminary step in developing this report on toxicology education in Canada, ACTOX conducted a survey of all universities in Canada. Questionnaires were sent to 65 Universities and University Colleges in Canada. The questionnaire asked for information relevant to undergraduate, post-graduate diploma and post-graduate degrees in Toxicology and related areas. Responses were compiled as received with editorial changes made only in an attempt to attain uniformity of presentation. No attempt has been made to evaluate the strengths or the weaknesses of any of the programs reviewed in this document other than to list the courses and to classify these into areas of specialization.

Although several universities offer programs in occupational health, these were not included in this survey of toxicology programs. It should also be noted that only the university-based educational programs were considered. Occasionally reported individual courses, dealing with toxicology, were not included in this survey.

3 MÉTHOLOGIE UTILISÉE

À titre d'étape préliminaire dans l'élaboration du présent rapport sur la formation en toxicologie au Canada, le CATOX a réalisé une enquête auprès de toutes les universités canadiennes. Des questionnaires ont été envoyés à 65 universités et collèges universitaires au Canada. Le questionnaire visait à recueillir de l'information sur les diplômes universitaires de premier, deuxième et troisième cycles ainsi que sur les diplômes d'études supérieures en toxicologie et dans les domaines connexes. Les réponses ont été compilées telles qu'elles ont été reçues, seules quelques modifications ayant été apportées pour uniformiser la présentation. Nous n'avons par cherché à évaluer les forces ou les faiblesses des programmes passés en revue dans le présent document; nous sommes limités à énumérer les cours et à les classer dans les domaines de spécialisation.

Bien que plusieurs universités offrent des programmes en médecine du travail, ces programmes n'ont pas été inclus dans la présente enquête sur les programmes de formation en toxicologie. Il faut également noter que seuls les programmes de formation universitaires ont été pris en considération. À l'occasion, des cours individuels qui nous ont été signalés et qui avaient trait à la toxicologie n'ont pas été inclus dans l'enquête.

4 DOCTORAL GRADUATE PROGRAMS IN TOXICOLOGY / PROGRAMMES D'ÉTUDES DU 3e CYCLE EN TOXICOLOGIE

The existing programs are shown in Table 1. Details are given in Annex 1.
Les programmes existants sont énumérés au Tableau 1. Les détails correspondants figurent à l'Annexe 1.

Table 1. **Doctoral Graduate Programs in Toxicology at Canadian Universities**
Tableau 1. **Programmes d'études de 3e cycle en toxicologie offerts par les universités canadiennes**

University Université	Degree in Toxicology *per se* Diplôme en toxicologie proprement dite	Subdiscipline/Sous-discipline	Area of Emphasis Domaine de concentration
Guelph*	Ph.D. in Toxicology (Collaborative Program)	Nutritional, Statistical, Chemical, Wildlife, Environmental, Biomedical Toxicology and Toxicopathology	
Laval	Doctorat en pharmacologie et toxicologie	Toxicologie des médicaments	Neurotoxicologie
Queen's	Ph.D. in Pharm.& Toxicology	Biochemical Tox. Occupational Toxicology	Hepatic; Pulmonary; Developmental; Neurotoxicology
Saskatchewan	Ph.D. in Toxicology (Collaborative Program)	Forensic Toxicology Nutritional Toxicology Environmental Toxicology Toxicopathology, Teratology, Metabolic Toxicology, Inhalation Toxicology	Immunotoxicology
Toronto*	Ph.D. in Toxicology (Collaborative Program)	Biomedical Toxicology and Ecotoxicology	
Western	Ph.D. in Pharmacology and Toxicology		Chemical, biochemical, developmental and target organ toxicology.

* New programs, just starting / Nouveaux programmes venant de commencer.

5 PROGRAMMES D'ÉTUDES DU 2e CYCLE EN TOXICOLOGIE / MASTER'S GRADUATE PROGRAMS IN TOXICOLOGY

The existing programs are shown in Table 2. Details are given in Annex 1.
Les programmes existants sont énumérés au Tableau 2. Les détails correspondants figurent à l'Annexe 2.

Tableau 2. Programmes d'études de 2e cycle en toxicologie offerts par les universités canadiennes
Table 2. Master's Graduate Programs in Toxicology at Canadian Universities

University Université	Degree in Toxicology *per se* Diplôme en toxicologie proprement dite	Subdiscipline/Sous-discipline	Area of Emphasis Domaine de
Guelph*	M.Sc. in Toxicology (Collaborative Program)	Nutritional, Statistical, Chemical, Wildlife, Environmental, Biomedical Toxicology and Toxicopathology	
Laval	Maitrise en pharmacologie et toxicologie	Toxicologie des médicaments	Neurotoxicologie
Queen's	M.Sc. in Pharmacology and toxicology,	Biochemical Tox. Pulmonary Toxicology Developmental toxicology Neurotoxicology	Hepatic Toxicology
Memorial	M.Sc. in General Toxicology	Drug, Heavy Metal & Pesticide Toxicology Ecotoxicology Metabolic Toxicology Mutagenesis	Endocrine Tox. Hepatic Tox. Pancreatic Tox. Renal Toxicology
Saskatchewan	M.Sc. in Toxicology (Collaborative Program)	Forensic Toxicology Nutritional Toxicology Environmental Toxicology Toxicopathology, Teratology, Metabolic Toxicology, Inhalation Toxicology	Immunotoxicology
Toronto*	M.Sc. in Toxicology (Collaborative Program)	Biomedical Toxicology and Ecotoxicology	
Western	M.Sc. in Pharmacology and Toxicology		Chemical, biochemical, developmental and target organ toxicology.

* Nouveaux programmes venant de commencer. New programs, just starting.

6 POST-GRADUATE DIPLOMA PROGRAMS IN TOXICOLOGY / PROGRAMMES DE DIPLÔME DE 2e CYCLE EN TOXICOLOGIE

The programs and courses required for the Post-Graduate Diploma programs in toxicology are listed in Table 3. Details are given in Annexes 1 and 2

Les activité et les cours requis pour les programmes de diplôme de 2e cycle en toxicologiesont énumérés au Tableau 3. Les détails correspondants figurent aux Annexes 1 et 2.

Table 3. Diploma Programs in Toxicology at Canadian Universities
Tableau 3. Programmes de diplôme de 2e cycle en toxicologie offerts par les universités canadiennes

University Université	Diploma/Diplôme	Subdiscipline/Sous-discipline
Concordia	Ecotoxicology	Aquatic Biology Aquatic Chemistry
S. Fraser	Env. Toxicology	Biomed. Toxicol. and Ecotoxicol. Aquatic Toxicology Pesticide Toxicology Biochem. Toxicology Inhalation Toxicology
Montreal	Toxicologie générale	Toxicologie des médicaments Toxicologie environnementale Toxicologie agro-alimentaire Toxicologie industrielle
Saskatchewan	Toxicology	General Toxicology

7 PROGRAMMES D'ÉTUDES DES 2e ET 3e CYCLES AVEC TRAVAUX DE RECHERHE EN TOXICOLOGIE OU DANS DES DOMAINES CONNEXES / POST-GRADUATE DEGREES WITH RESEARCH AREAS IN OR RELATED TO TOXICOLOGY

Les différentes options de formation traditionnelles sont présentées sous forme de résumé et les points saillants sont énumérés au Tableau 4.

This listing of the traditional training options is provided in summary fashion only, and the salient features are listed in Table 4.

Tableau 4. Programmes d'etudes des 2e et 3e cycles avec travaux de recherhe en toxicologie ou dans des domaines connexes

Table 4. Graduate Programs at Canadian Universities with Research Areas in or Related to Toxicology

University Université	Degree/Diplôme	Area of Emphasis/Domaine de concentration
Alberta	M.Sc., Ph.D.	Biomedical Science, Pharmacology
Concordia	M.Sc., Ph.D.	Ecotoxicology, Chemodynamics of toxicants in the environment
Dalhousie	M.Sc.	Biology, Pharmacology, Environmental Studies
Guelph	M.Sc., Ph.D.	Chemical toxicology, Biomedical toxicology, Pesticide/Environmental toxicology
McGill	M.Sc., Ph.D.	Reproductive toxicology, Chemical toxicology
McMaster	M.Sc., Ph.D.	Metal toxicology and carcinogenesis
Memorial	M.Sc.	Biochemical and pharmacological toxicology
Montreal	M.Sc., Ph.D.	Occupational and environmental toxicology, Pharmacology, Nutrition, Ecotoxicology
Québec	M.Sc.	Chimie
(à Montréal)	M.Sc.	Biologie - Cytotoxicologie - Génotoxicologie - Immunotoxicologie - Toxicité pulmonaire
	Ph.D.	Sciences de l'environnement (areas of emphasis as in M.Sc. Biology)
Queen's	M.Sc., Ph.D.	Biochemical Toxicology, Occupational Toxicology, Environmental Toxicology.

Saskatchewan	M.Sc.,Ph.D.	Forensic toxicology, Metabolic toxicology
Simon Fraser	M.Sc.,Ph.D.	Aquatic toxicology, Pesticide toxicology, Biochemical toxicology, Drug toxicology, Inhalation toxicology.
Toronto	M.Sc.,Ph.D.	Pharmacology/toxicology, Environmental toxicology, Biomedical toxicology
Waterloo	M.Sc.,Ph.D.	Earth Sciences: Environmental Geology, Contaminant Hydrogeology, Aquatic Toxicology: Microbiology, Microbiological degradation of toxicants
Western	M.Sc.,Ph.D.	Chemical and biochemical toxicology, developmental toxicology, metal toxicology, environmental and clinical toxicology.

8 PROGRAMMES D'ÉTUDES DU 1er CYCLE EN TOXICOLOGIE / UNDERGRADUATE PROGRAMS IN TOXICOLOGY

Undergraduate programs in Toxicology are shown in Table 5. Details are listed in Annex 3.

Les programmes d'études du 1er cycle en toxicologie sont énumérés au Tableau 5. Les détailes correspondants figurent à l'Annexe 3.

Table 5. Undergraduate Toxicology Programs at Canadian Universities
Tableau 5. Programmes d'études du 1er cycle en toxicologie offerts par les universités canadiennes

University/Université	Degree/Diplôme	Area of Emphasis/Domaine de concentration
Guelph	B.Sc. (Hons)	Biomedical, Chemical, Nutritional, Environmental, Genetic and Mathematical Toxicology.
Montréal	Certificat	Toxicologie industrielle et de l'environnement (Programmme d'éducation permanente pour adultes)
Université Québec a Montréal	Baccalauréat en biologie	Physiologie et toxicologie
Queen's	B.S. (Hons)	Life Sciences
Simon Fraser	B.Sc. (Minor)	General Toxicology and Ecotoxicology
Western Ontario	B.Sc. (Hons)	Pharmacology and Toxicology

DETAILS OF POST-GRADUATE PROGRAMS (M.Sc. AND Ph.D.) COURSES IN TOXICOLOGY

1 University of Guelph
M.Sc. and Ph.D. in toxicology (collaborative program).

Areas of Emphasis: As per collaborating departments.

Admission Requirements
Admission to participating Department and approval of program admissions committee.

Program
Students must be admitted by a participating Department and must register and meet the academic requirements (courses and examinations) of the home Department. In addition, students must take the courses (as described below), and students must conduct research in the area of toxicology and write a thesis under the guidance of a supervisor and supervisory committee in the student's home Department.

Participating Departments: Nutritional Sciences, Zoology, Chemistry and Biochemistry, Mathematics and Statistics, Environmental Biology, Soil Sciences, Biomedical Sciences and Pathology

Courses required for graduation

9406200 ADVANCED TOPICS IN TOXICOLOGY

At least three of:

1907330 Selected Topics in Biochemistry
1907610 Selected Topics in Organic Chemistry
71-432 Nutrition and Abnormal Metabolism
71-451 Toxicological Aspects of Nutrition
94-200 Principles of Toxicology
94-336 Environmental Chemistry and Toxicology
94-400 Medical Toxicology
94-410 Toxicological Pathology
94-420 Topics in Toxicology
94-459 Biochemical Toxicology
9806200 Carcinogenesis
9806440 Toxicology
9806480 Pharmacodynamics and Pharmacokinetics

Course descriptions

1907330 Selected topics in Biochemistry
Discussion of specialized topics related to the research interests of the members of the Centre: for

example, such topics as transport mechanisms in biological systems; energy transformation in biological systems; macromolecules of biochemical origin; medical aspects

1907610 Selected Topics in Organic Chemistry
Two or three topics from a range including: bio-organic chemistry; environmental organic chemistry; free radicals; heterocyclic molecules; molecular rearrangements; organometallic chemistry; photochemistry; natural products.

71-432 Nutrition and Abnormal Metabolism
A discussion of the role of nutrition in the development of metabolic disorders and of inherited defects in the absorption, transport or metabolism of nutrients in man and animals. Department of Nutritional Sciences.
Prerequisite: 71-319 or 71-321.

71-451 Toxicological Aspects of Nutrition
The occurrence, metabolism and nutritional implications of non-nutrients, additives and environmental pollutants in foods and feeds. Influence of drugs, environmental contaminants and natural toxicants on nutritional requirements. Department of Nutritional Sciences.
Prerequisite: 71-319 or 71-321.

94-200 Principles of Toxicology
This course will establish the scientific principles underlying the toxic actions of various substances and will introduce the various challenges within the field of toxicology. The chemical nature of injurious substances, their uptake and metabolism by non-target organisms, and their mode of toxic action will be studied in addition to the methods used in safety evaluations and risk assessment. Recommendation: students are advised to register in 89-204 concurrently if they lack statistics. Department of Biomedical Sciences.

94-336 Environmental Chemistry and Toxicology
The chemistry of the natural environment; the influence of pollutants upon the environment, including methods of introduction of pollutants to, and removal of pollutants from, the environment. This course is also listed under 19-336, Chemistry and Biochemistry. Credit cannot be held for both.
Prerequisites: 19-101, 19-179.

94-400 Medical Toxicology
The toxicology of mammalian body systems: dose-response, mechanisms and systemic sites of action of major groups of chemical toxicants. The course is designed for students majoring in toxicology. Department of Biomedical Sciences.
Prerequisites: 72-300, 94-200.

94-410 Toxicological Pathology
Evaluation of the pathologic responses of cells and tissues to toxic compounds. The course is designed for students majoring in toxicology. Department of Pathology.
Prerequisite: 73-360.

94-420 Topics in Toxicology

Topics in toxicology will consists of oral presentations by students, faculty members, and guest lecturers. The emphasis will be on the broad integrative aspects of toxicology with particular reference to the whole organism and higher levels of natural systems. This course is designed for B.Sc. Honors Toxicology students in their 7th or 8th semester. Departments of Environmental Biology and Zoology.

Prerequisites: 19-201, 19-336, 94-200.

94-459 Biochemical Toxicology

The molecular mechanisms of action of carcinogens and other toxic compounds. Enzymes of biotransformation, including a detailed study of cytochrome P-450. Interactions of reactive species with DNA and other macromolecules. Designed for students specializing in toxicology, chemistry, or biochemistry. Department of Chemistry and Biochemistry.

Prerequisites: 19-101, 19-358, 19-359, and 40-200.

9806200 Carcinogenesis

A seminar course on cancer induction. A multidisciplinary approach is taken encompassing epidemiology, genetics, chemical and biochemical considerations. Short-term mutagenicity testing is discussed and frontiers in cancer research are examined.

9806480 Pharmacodynamics and Pharmacokinetics

Molecular mechanisms of drug action. Absorption, distribution, biotransformation and excretion of drugs. Factors modifying drug effects. Mathematical analysis of drug dosage required.

9806440 Toxicology

Chemical compounds injurious to animals and man; toxicity testing, teratogens, carcinogens, factors influencing toxicity, toxic drug interactions. Mechanism of action, metabolism, and principles of antidotal treatment.

2 Université Laval
Maîtrise et doctorat en pharmacologie et toxicologie

Domaine de concentration: Pharmacologie et toxicologie

Programme
Maîtrise en pharmacologie et toxicologie

Exigences D'Admission

L'admission à ce programme exige que le candidat soit détenteur d' un diplôme de baccalauréat ou l'équivalent et dépend des ressources financières et humaines disponibles. Bien qu'une moyenne cumulative de 3.5 sur 5.0 au niveau du premier cycles ou l'équivalent soit une condition normales d'admission, l'ensemble du dossier est considéré par le Comité d'admission et de supervision.

Il peut yavoir des exigences particulières relatives au champ et domaine d'études et de recherche choisi.

Ce programme accepte de nouveaux étudiants aux trimestres suivants: automne, hiver et été.

Choix du Projet de Recherche

Avant l'admission, le candidat doit avoir déterminé le champ et domaine d'études et de recherche choisi et avoir trouvé un professeur qui accepte d'être son directeur de recherche. De plus il doit fournir au comité d'admission et de supervision un résumé de son projet de recherche avant d'être admis dans son programme.

Nombre et répartition des crédits du programme

Ce programme comporte 48 crédits répartis comme suit:

Cours propres au programme	8 crédits
Mémoire	40 crédits

Durée du programme

Ce programme a une durée normale de quatre trimestres à temps complet

Cours du Programme

Un tronc commun de cours pour tous les étudiants est d'abord exigé. Chacun des champs et domaines d'études et de recherche à ces cours obligatoires correspondant à un minimum de 7 crédits et éventuellement à des cours optionnels. Les autres cours, s'il y a lieu, peuvent être obtenus à l'intérieur du programme, dans les autres programmes de la Faculté de médecine ou ailleurs à l'Université Laval. Des cours à l'extérieur peuvent être envisagés s'ils ne sont pas disponibles dans notre milieu.

A. Cour obligatoire propre au programme

NMC	Cr	Titre
MDX-62614	3	Biostatistique 1

Cours qui peuvent être suivis pour crédit

Pharmacologie et Toxicologie

PHC-61897	2	Théories des récepteurs
PHC-61899	2	Principes de pharmacologie et toxicologie
PHC-62565	2	Toxicologie avancée
PHC-62355	1	Sujets spéciaux (Pharmacologie)
PHC-61898	2	Méthodes de résonnances magnétiques en sciences biologiques
PHC-62724	1	Pathologies et médicaments
PHC-62356	2	Sujets spéciaux (Pharmacologie)
PHC-63852	1	Neuro-psychotoxicologie
PHC-63853	1	Neuro-psychopharmacologie

Programme
Doctorat en pharmacologie et toxicologie

Exigences d'admission

L'admission à ce programme exige que le candidat soit titulaire d'un diplôme de maîtrise ès sciences dans un domaine connexe ou possède une formation jugée équivalente. Une scolarité complémentaire peut être exigée.

Un candidat peut être admis au programme de doctorat sans être tenu de franchir toutes les étapes habituelles de la maîtrise si le Comité d'admission et de supervision le lui permet.

Ce programme accepte de nouveaux candidats aux trimestres suivants: automne, hiver et été.

Choix du projet de recherche

En faisant sa demande d'admission, le candidat doit indiquer le domaine dans lequel il entend se spécialiser. Il doit être fixé sur le choix de son directeur de recherche et être accepté par celui-ci. Ce choix et le projet de recherche doivent être approuvés par le Comité d'admission et de supervision avant l'inscription.

Nombre et répartition des crédits du programme

Ce programme comporte 96 crédits répartis comme suit:

Cours propres au program	6 crédits
Thèse	90 crédits

Durée du program

La durée normale de ce programme est de huit trimestres à temps complet incluant les trimestres d'été

Un maximum de deux crédits sera accordé pour la préparation de deux séminaires sur un sujet donné.

Cours qui peuvent être suivis pour crédit
Maîtrise et doctorat en pharmacologie et toxicologie

3 Memorial University
M.Sc. in Toxicology (Interdisciplinary Program)

Area of Emphasis: Drug, heavy metal and pesticide toxicology, Metabolic Toxicology, Mutagenesis, Ecotoxicology.

Participating Departments - Biochemistry, Biology, Chemistry, Medicine, Pharmacy, Psychology.

Admission Requirements - B.Sc. (Hons) or equivalent. Approval by the program admissions committee.

Program - Students adopt the department of their supervisor as the home department and participate in all the activities of that department. However, the toxicology program being interdisciplinary in nature, requires students to take core courses and to participate in seminars with students from other departments who are also registered in the program.

Courses Offered - All toxicology students are required to take the three core courses outlined below:

Toxicology 6670
General Principles of Toxicology. The biophysical and/or biochemical bases of toxicities. Pharmacokinetics and pharmacodynamics of selected groups of toxicants. Safety evaluation and risk assessment.

Toxicology 6680
Target Organ Toxicology. Adverse effects of physical, chemical and biological agents on cells, tissues, organs and organ systems.

Toxicology 6690
Toxicology Seminars. Current topics of concern in toxicology.

In addition to the above core courses, the supervisory committee may require students to take one or more of the following graduate courses:

Biochemistry 6600 - Metabolic Toxicology
Biochemistry 6420/Medicine 6290 -DNA: Structure and Function of Genes
Biology 7600 - Effect of Organic and Inorganic Pollutants on Biological Systems
Biology 7601 - Principles and Control of Pest Organisms
Chemistry 6100 - Advanced Analytical Chemistry I
Chemistry 6101 - Advanced Analytical Chemistry II
Chemistry 6600 - Applications of Inorganic, Organic and Organometallic Chemistry to Toxicology
Medicine 6190/Pharmacy 6004 - Pharmacology & Pharmacokinetics
Medicine 6200 - Design and Analysis of Biomedical Experimentation
Pharmacy 6005 - Drug Toxicology
Psychology 6203 - Behavioural Pharmacology
Psychology 6210 - Behavioural Analysis of Toxins

4 Queen's University
M.Sc. and Ph.D. in Pharmacology and Biochemical Toxicology

Areas of Emphasis: Toxicology, hepatic toxicology, pulmonary toxicology, developmental toxicology, neurotoxicology.

Program

M.Sc. PROGRAM

Credit Requirements

Outlined in the Calendar of the School of Graduate Studies and Research. The Department may make additional recommendations.

Extra-Departmental Courses

Physiology and Biochemistry:
The graduate student will be required to take Biochemistry 800 and Physiology 812.

Biostatistics:
A working knowledge of biostatistics is vital to the Pharmacologist. Therefore, all students who have not taken such a course will be required to take a course in this field which gives consideration to experimental design, data analysis and data interpretation.

Electives:
Students are encouraged to consider elective courses, not only in the traditional allied disciplines (histology, neuroanatomy, endocrinology, advanced physiology, biochemistry, etc.), but also in other disciplines (immunology, genetics, behavioral science, computer science, pathology, biophysics, bioengineering, etc.).

Pharmacology Courses

The following courses are offered in the Department. Full descriptions of these courses can be found in the Graduate Calendar.

PHAR-810 Advances in Neuropharmacology (1/2 credit)
PHAR-811 Principles of Pharmacology and Toxicology (1/2 credit)
PHAR-812 Methodology in Pharmacology (1 credit)
PHAR-813 Medical Pharmacology (1 credit)
PHAR-814 Principles in Toxicology (1/2 credit)
PHAR-815 Selected Topics in Toxicology (1/2 credit)
PHAR-820 Principles of General Pharmacology (1 credit)
PHAR-821 Pharmacology Seminar Program (1/2 credit)

Normally at least one of 810, 811 or 815 and both 812 and 821 must be included in an M.Sc. program.

Required Courses in Pharmacology:
PHAR-812
PHAR-821
PHAR-810, Phar-811, or Phar-815 (offered alternate years)
PHAR-813 or Phar-820

Courses

Phar-799 Introduction to Animal Care.

This non-credit seminar is given early in the academic year and is obligatory for all students undertaking teaching and/or research involving the use of vertebrate animals. The seminar will cover ethical and legal obligations related to the use of animals; standards of care, source, and quality of animals; and choice of biomedical models. Students need to take this seminar only once. NOTE: In this department, the seminar will bo covered during the first three lectures in the course PHAR-812, Methodology in Pharmacology. Students are required to register for both for the sake of their records. Three hours maximum. *Animal Care Service.*

Phar-810 Advances in Neuropharmacology.

Selected topics in peripheral and central neuropharmacology with emphasis on the mechanism of action of drugs. Topics covered: drug receptor theory; drugs affecting ion channels, nerve muscle interactions; axonal transport; neurotoxins, neuropharmacology of synaptic transmitters and neuropeptides; role of neurotransmitters in neurological and psychiatric disorders, e.g. epilepsy, dementia, Parkinson's and Huntington's Disease, schizophrenia; psychopharmacology of amphetamines and ethanol.

Prerequisites: Phgy-312 or equivalent. Permission of the Department required.

Phar-811 Principles of Pharmacology and Toxicology.

Topics covered: bonds between receptors and ligands, pathways of xenobiotic metabolism, pharmacokinetics, mediators of drug action, free radical toxicity, immunopharmacology, effects of xenobiotics on cell heredity, mechanisms of action of pulmonary, hepatic and renal toxicity.

Prerequisites: BCHM-310 or equivalent. Permission of the Department required.

Phar-812 Methodology in Pharmacology.

Topics covered: animal experimentation; isolated tissue preparations; cell culture; radioisotopes in pharmacology; application to pharmacology of physical techniques: gas-liquid chromatography, high-performance liquid chromatography, mass spectrometry, infrared and nuclear magnetic resonance spectrometry.

Prerequisites: Basic biochemistry, physiology, pharmacology. Permission of the department required.

Full course, fall and winter; lectures and laboratories.

Phar-813 Medical Pharmacology

Topics covered: principles of drug action; autonomic pharmacology; agents affecting the cardiovascular system; diuretics; chemotherapy, neuropharmacology and agents affecting the endocrine system. Students will explore one area of pharmacology in depth and write an essay on the topic.

Prerequisite: Permission of the Department required.

Full course, winter term; lectures and laboratories.

Phar-815

This half course will consist of lectures and seminars and directed readings on the mechanisms of action of toxicants. Topics covered will include toxicological evaluation, effects of toxicants on organ systems, and an examination of selected toxic agents in detail.
Prerequisites: BCHM-310 or equivalent; may be taken concurrently.
Permission of the Department required.
Half course, winter term; lectures and seminars. Given in years with even numbers.

Phar-820 Principles of General Pharmacology

This course consists of lectures, laboratory demonstrations, laboratory projects, and an essay designed to explore in depth a topic in basic pharmacology. The course deals with the following topics: principles of drug action, autonomic pharmacology, agents affecting the cardiovascular system, diuretics, chemotherapy, neuropharmacology, psychopharmacology, toxicology, and agents affecting the endocrine system.
Prerequisites: Basic biochemistry and physiology. Permission of the Department required.
Full course, fall and winter; lectures and laboratories.

Phar-821. Pharmacology Seminar Program

Topics covered: selected topics in pharmacology will be presented and discussed by staff, students, and visiting lecturers.
Prerequisites: Basic biochemistry and physiology. Permission of the Department required.
Fall and winter: one hour per week.

Phar-899 Master's Thesis Research

Phar-999 Ph.D. Thesis Research.

Pharmacology 813:

This course includes material covered in Pharmacology 520 which is offered to the second-year medical students, and it is expanded to include an in-depth study of one particular topic on which the student will write a paper or present a seminar. The examination for graduate students will be taken in conjunction with students taking Pharmacology 520. A minimum grade of 70% must be achieved in this course. Pharmacology 820 may be taken in place of Pharmacology 813 with the permission of the Department.

Exemptions from Pharmacology 813:

i Queen's Students:
Those students from Queen's who have taken Pharmacology 420 or 520 and achieved a minimum final grade of 70% will not be required to take Pharmacology 813 or 820. However, they are encouraged to attend lectures in this course and familiarize themselves with aspects of the subjects that were not covered in Pharmacology 420.

ii Students from Other Universities:
A decision as to whether to take Pharmacology 813 or 820 will be made after considering material in other courses taken by the student.

Ph.D. PROGRAM

Credit Requirements

Credit requirements for Ph.D. students are as above and in addition include the following.

Mathematics:

All Ph.D. candidates are required to have previously completed the equivalent of Introductory Calculus after entrance in the program. Students are expected to complete this minimum requirement in mathematics early in the program.

Pharmacology 799, 812, and 821:

All students in the Ph.D. program are required to take Pharmacology 799, 812, and 821.

Pharmacology 810, 811, and 815:

Pharmacology stream students are required to take Pharmacology 810 and 811.

Toxicology stream students are required to take Pharmacology 811 and 815.

Exemption from any of these courses is dependent on the approval of the Department.

5 University of Saskatchewan
M.Sc. and Ph.D. in Toxicology (Collaborative Program)

Areas of Emphasis: Nutritional Toxicology, Environmental Toxicology, Analytical Toxicology, Clinical Toxicology, Forensic Toxicology, Immuno-toxicology, Teratology, Alternative Methods, and Toxicopathology.

Participating Colleges/Departments/Institutions
Toxicology Group, an interdisciplinary body consisting of faculty members from a number of University departments as well as scientists from other laboratories on campus.

Admission Requirements
A recognized undergraduate degree such as an M.D., D.V.M., D.D.S., B.S.P., B.Sc., B.S.A., etc., is required. Biochemistry and Physiology are prerequisites. Courses in environmental chemistry, pathology and pharmacology are desirable.

Program
M.Sc. - 15 credits from the core courses; additional courses as decided by the supervisory committee.
Ph.D. - 21 credits, at least 15 credits, including Applied Toxicology (Tox 860.3) must be taken from the core courses. A laboratory animal care course (GSR 988) is mandatory for students who will use animals in their programs or future careers. Research work resulting in an acceptable thesis is also required.

Core Courses

Offered each year:

VTP 836.5 General Toxicology I
VTP 837.5 General Toxicology II
PHARM 856.3 Forensic Toxicology
TOX 990 Toxicology Seminar

Offered in alternate years:

ANAT 816.3 Teratology
ANSC 825.3 Nutritional Toxicology
VTP 833.3 Subclinical Toxicology
TOX 860.3 Applied Toxicology
PHARM 854.3 Metabolic Toxicology
APMC 825.3 Carcinogens-Mutagens
VTPA 841.3 Toxicopathology
TOX 810.3 Radiation and Radionuclide Toxicology

Additional Courses
There is a large selection of graduate courses offered in various sciences which are available to supplement core courses listed above.

Core Course Descriptions

VTP 836.5 General Toxicology I

General principles of toxicology - including principles of toxicokinetics and toxicodynamics, factors influencing toxicity, mechanisms of actions of poisons and antidotes, methods of toxicity evaluation. Toxicology of common poisons, e.g., pesticides, metals and metalloids, toxic gases, poisonous plants, zootoxins, etc. This course aims at the basic science aspect of toxicology and not at clinical diagnosis or treatment of specific toxicoses.

VTP 837.5 General Toxicology II

Four areas are emphasized: 1) systemic toxicology - types of injury produced in specific organs/systems by toxic agents and agents which produce these effects; 2) environmental toxicology - entry, persistence, amplification and effects of environmental pollutants; 3) subclinical toxicosis by environmental contaminants, carcinogenesis, teratogenesis, mutagenesis; 4) nutritional toxicology - methodology, national and international standards and consideration of natural and man-made toxic substances.

PHARM 856.3 Forensic Toxicology

A course dealing with the analytical procedures involved in the detection of chemicals and drugs in the body tissues and fluids, and the identification of drugs of abuse. Appropriate analytical chemical techniques are discussed and used during the practical component of the course.

TOX 990 Toxicology Seminar

Reviews of literature and recent investigations. Graduate students are required to attend and to present seminars.

ANAT 816.3 Teratology

The course will consider all aspects of abnormal embryonic and fetal development. While it will deal mainly with dysmorphology, development of functional abnormalities will be considered. Laboratory exercises will be selected for maximum value in illustrating principles.

ANSC 825.3 Nutritional Toxicology

Naturally occurring toxicants. Bacterial toxins and mycotoxins. Additives and residues. Contaminants. Drug nutrient interrelationships. Nutrient toxicity. Safety and regulatory aspects.

VTP 833.3 Subclinical Toxicology

This course will discuss subclinical manifestations to toxic agents. The emphasis will be on immunological and behavioral alterations produced by variety of chemical agents. Animal models and testing methods used to evaluate the effects will be discussed, along with various public health considerations and significance.

TOX 860.3 Applied Toxicology

This course will provide students an opportunity to evaluate practical problems associated with various aspects of toxicology. Students will be presented with specific toxicological questions or concerns which will be examined using research information and library facilities. Prerequisite: VTP 836, 837 and/or permission of the instructor. Other courses in Toxicology are highly desirable.

PHARM 845.3 Metabolic Transformations of Xenobiotics

An advanced study of the basic principles of the metabolism of foreign compounds in mammals. The xenobiotics covered will include drugs, food additives, agricultural chemicals and industrial chemicals. The detoxification and toxicological implications of metabolism are emphasized.

APMC 825.3 Carcinogens and Mutagens

This course is designed to provide the student with some understanding of carcinogens and mutagens, their mechanism of action at organismic, cellular and molecular levels, and of their testing and assessment. Short seminar discussions of current developments will be included.

TOX 810.3 Radiation and Radionuclide Toxicology

The basic properties of ionizing radiation, the interaction of radiation with matter, radiation detection, units and dosimetry are described. The natural radiation environment, radioactivity and its distribution and the accumulation by chemical and biological processes are discussed. The biological effects of radiation, particularly carcinogenesis, are presented both at the epidemiological and molecular level.

VTPA 841.3 Toxicopathology

This course is given in alternate years. A review of the principles of toxicopathological testing and the most important aspects of general pathobiology will be followed by a presentation of toxic injury to specific body systems.

6 University of Toronto
M.Sc., Ph.D. in Toxicology (Collaborative Program)

Areas of Emphasis: Biomedical Toxicology and Ecotoxicology.

Participating Departments
Anatomy, Botany, Chemical Engineering and Applied Chemistry, Clinical Biochemistry, Community Health, Dentistry, Forestry, Geography, Medical Biophysics, Microbiology, Nutritional Sciences, Pathology, Pharmacology, Pharmacy, Physiology, Psychology and Zoology.

Admission Requirements
Admission to participating Department.

Program
Students in the program must enrol in one of the participating departments and follow a program of study acceptable to both the participating department and the toxicology program. Students must complete a research thesis and the topic must be in the area of toxicology.

Courses Required for M.Sc.

Core Courses

JNP 1016H Graduate Seminar in Toxicology
JNP 1014Y Interdisciplinary Toxicology
JNP 1017H Molecular and Biochemical Basis of Toxicology
JBE 1434Y Applied Ecology (Ecotoxicology stream only)

Specific courses are not required for the Ph.D. program. These are decided in consultation with the supervisory committee.

Course Descriptions

PCL473Y. Interdisciplinary Toxicology
Traditional and contemporary problems in toxicology: general aspects, methodology, nature of toxic damage, general biological problems, poisons, applications and social policies.
Prerequisite: BCH 320Y/321Y; PCL 362H, 363H and permission of Department. Recommended Corequisite: CLB 404H, 405H.

PCL481H. The Molecular and Biochemical Basis of Toxicology
The biochemical principles and molecular mechanisms underlying the toxicityof drugs and foreign agents. The sequence of events at the molecular level leading to impairment of cell function and the factors which determine and affect toxicity.
Prerequisite: PCL 362H; BCH 320Y.

7 University of Western Ontario
M.Sc. and Ph.D. in Pharmacology and Toxicology

Areas of Emphasis: Pharmacology and Toxicology.

Admission
The Department of Pharmacology and Toxicology offers programs leading to two degrees, M.Sc. and Ph.D. Students entering the program after completion of a B.Sc. (Hons.) (or equivalent), M.D., D.D.S., D.V.M., degree will be admitted to the M.Sc. program. A M.Sc. candidate may be allowed to be transferred to the Ph.D. program following successful completion of a Ph.D. qualifying examination and approval by the departmental Graduate Studies Committee. Students already holding an M.Sc. degree from U.W.O. or another institution will be considered for enrollment directly into the Ph.D. program.

Degree Requirements
Although the emphasis is on research in the graduate programs, students are required to take formal courses. In addition to the core courses in pharmacology and toxicology, students are encouraged to consider extradepartmental courses in chemistry, biochemistry, pathology, physiology, epidemiology and molecular biology. The number and selection of these courses will depend in part upon the student's previous training.

Core Course Description

512a/b. Organ Function and Toxicology.
Mechanisms of chemical toxicity on mammalian organ function as well as methodology evaluation of organ toxicity.

514. M.Sc. Comprehensive

530. Medical Pharmacology.
The course of lectures deals with the absorption, distribution, metabolism and excretion of drugs, the mechanism of action, therapeutic uses, contraindication and toxic effects of the clinically important drugs.

532a/b. Cardiovascular Pharmacology.
Advanced topics in cardiovascular pharmacology. Seminar and tutorial.

541y. Seminar.
The preparation of essays and the presentation of scientific reports or papers on assigned topics in pharmacology and toxicology.

560b. Environmental Toxicology.
Natural and man-made environmental hazards, and the concept of risk - benefit analysis will be discussed. Emphasis will be placed on the role of agriculture and industry in environmental quality.

562a. Principles of Pharmacology.

A course which develops the role of the receptor in the production of drug response, and examines the factors that influence the presence of drugs in the body and the time-course of drug action. Individual reading assignments required.

563a. Principles of Toxicology.

Chemical, biochemical and pharmacological mechanisms of toxicity. Application of basic principles in problem-solving will be emphasized.

564a/b. Pharmacology of the Autonomic Nervous System.

Principles of chemical transmission of nerve impulses and mechanisms of drug effects involving modification of the activity of the autonomic nervous system. Individual reading assignments required.

566a/b. Biochemical Basis of Neuropharmacology.

An advanced course dealing with the mechanisms regulating synthesis and release of neuroactive substances from nerves and the interaction of drugs and chemicals with these mechanisms. Topics include: Cholinergic, monoaminergic and peptidergic function, co-transmission and pre-junctional modulation.

567a/b. Applied Pharmacokinetics.

A course of lectures and problem-solving sessions that emphasize the concepts and applications of modern pharmacokinetics.

570y. Advanced Clinical Pharmacology.

This course reviews recent advances in pharmacology and their relevance to the therapeutic application of drugs.

577a/b. Pharmacology of the Central Nervous System.

This course deals with the major classes of drugs affecting the central nervous system and their relationships to neuropsychiatric disorders.

580. Laboratory and Tutorial.

A course of training in the techniques employed in modern pharmacology and toxicology investigations. Opportunity for original projects will be provided. A tutorial will supplement both lecture and laboratory work.

590. M.Sc. Thesis.

610. Advanced Topics in Pharmacology and Toxicology.

This course consists of seminar presentations; critique of scientific papers; preparation and defense of a research proposal.

614. Ph.D. Comprehensive.

690. Ph.D. Thesis.

DETAILS OF POST-GRADUATE DIPLOMA PROGRAMS AND COURSES IN TOXICOLOGY

1 Concordia University
Diploma in Ecotoxicology

Areas of Emphasis: Ecotoxicology Fate of Pollutants in Ecosystems and the Impact of Polutants on Natural Biological Communities.

Admission Requirements — A B.Sc. in Biology or Chemistry or equivalent.
A G.P.A. of 2.7 or better is normally required.

Program
A minimum of 32 credits are required. Each course has a value of 4 credits. Courses are available in the evening, allowing those in the workforce to participate.

Courses which may be Taken for the Diploma

BIOL 550 Ecotoxicology
This course presents a survey of the ecological behaviour and effects of toxicants in nature. It considers the impact of pollutants on various ecosystems, including freshwater, marine, and terrestrial. Topics include the effects of certain categories of toxicants on organisms, as well as their populations and communities. The major sources and environmental pathways of pollutants will be discussed. Of particular interest will be the subjects of bioaccumulation and biomagnification of pollutants in trophic systems.

BIOL 551 General Principles of Toxicology
This course deals with the origin and scope of toxicology. It introduces students to basic toxicity criteria required for safety and risk assessments. Principles which govern exposure and response to toxicants are discussed. Other topics include an introduction to the processes which determine the fate of a toxicant in a target organism. Modifying factors of toxicity are considered. The course concludes by surveying the effects of some representative toxicants.

BIOL 571 Design of Ecotoxicology Studies
This course presents a research rationale for toxicity testing as required for risk assessments of environmental pollutants. It initially presents a format for on site monitoring of contaminated environments. However, a major portion of the course considers laboratory approaches designed to provide a predictive capacity for hazard assessments of environmental pollutants. The strategy includes quantitative structure-activity relationship (QSAR) determinations, mode of action (MOA) screening, surrogate species testing for interspecies extrapolations and quantitative methods for predicting the toxicity of mixtures. The course concludes with a discussion of how the information gathered by these various procedures can be integrated and applied to risk assessments.

CHEM 518 Analytical Methods in Ecotoxicology

This course surveys the main analytical techniques for the determination of trace levels of common environmental contaminants, including metals, organic solvents, alcohols, pesticides, etc. Procedures for the collecting, storing and preparing of water, air, soil and biological samples for chemical analyses will be discussed. Students will be introduced to the operational procedures of various instruments.

CHEM 533 Multivariate Statistics

This course begins with a brief review of univariate and bivariate statistics and students are introduced to the SPSSx, computer-based system for application to case problems. A survey of advanced statistical methods follows, beginning with multiple regression analysis, proceeding to analysis of covariance, discriminant and cluster analysis, factor analysis and repeated measures of analysis of variance.

CHEM 575 Toxicokinetics and Biodegradation Processes

A study of processes governing the fate of toxic substances in target organisms. Mechanisms of absorption, distribution, storage and excretion are discussed. Metabolic routes for the transformation of toxicants are examined in detail. Various mechanisms leading to synergisms, potentiation or antagonisms are proposed. Differences in metabolic processes between species will be examined.

CHEM 576 Toxicodynamics and Target Organ Disease

A study of the selective action of toxicants on bodily organs associated with the excretory, respiratory, nervous, reproductive, digestive, cardiovascular, and locomotory systems. Methods of diagnosis will be discussed.

CHEM 580 Socio-Economic, Legal and Industrial Aspects of Environmental Toxicology

Topics include definitions of pollution, environmental quality criteria and standards. Various use-benefit concerns that shape human perception, and orientation to the natural environment will be examined. An account of the various regulations at the provincial, federal and international levels that concern the management of the environment against pollution will be presented. Pollution treatment processes and industrial waste against management techniques will be surveyed with the emphasis on case studies.

BIOL 532/Ecotoxicology Subject: Intermediate Statistics

In this course, the student will develop an understanding of, as well as an appreciation for, two fundamental statistical procedures - multiple regression and analysis of variance. A quick review of basic elementary statistics, based on the view that a good foundation in elementary statistics makes for an easier understanding and utilization of advanced statistical procedures, will be followed by an intensive study of regression, multiple regression and analysis of variance techniques. The ultimate goal of the course is to give students sufficient understanding of statistical procedures that they will encounter little difficulty understanding discussion of statistical procedures in most texts and journals. At each step of the course, a basic understanding of the statistical mechanisms involved in the procedures will be encouraged while recognizing that the effective application of the techniques is the primary goal of the course. Because of the practical side of the course, computer assisted statistical analysis of data will be an integral part of the presentation.

SLOT COURSES (ONLY GIVEN ON OCCASION)

CHEM581/Selected Topics in Environmental Chemistry and Ecotoxicology.

BIOL 572/Selected Topics in Ecotoxicology.

2 Simon Fraser University
Post-Baccalaurate Diploma in Environmental Toxicology

Areas of Emphasis: Ecotoxicology, Biomedical Toxicology and Environmental Health.

Admission Requirements
Completion of a Bachelor's degree (in one of the sciences) from a recognized university with a minimum graduation grade point average of 2.0, or the equivalent.

Program Requirements (Prerequisites)

Completion of lower level prerequisite CHEM 252 or equivalent.

Completion of upper level prerequisite BISC 301 or BICH 302 or equivalent.

Successful completion of an approved program comprised of at least 30 credit hours of graduate and upper level undergraduate courses.

Minimum grade point average of 2.5 on courses applied toward the diploma.

Completion of the diploma within five years of admission to the program.

Courses Required for Diploma

Required courses

BISC 312-3 Environmental Toxicology I
BISC 313-3 Environmental Toxicology II
BISC 432-3 Chemical Pesticides and the Environment
BISC 650-3 Industrial Toxicology
BISC 651-3 Food and Drug Toxicology
BISC 652-3 Problem Analysis in Environmental Toxicology
BISC 846-3 Insecticide Chemistry and Toxicology

and two of

BISC 445-3 Environmental Physiology of Animals
CHEM 371-3 Chemistry of the Environment I
GEOG 319-3 Mass Transfer in the Biosphere

Optional courses: (choose one)

BISC 329-4 Introduction to Experimental Techniques
BISC 449-3 Experimental Techniques III: Histochemistry
CHEM 357-3 Chemical and Industrial Methods of Identification of Organic Compounds
CHEM 416-3 Modern Methods of Analytical Chemistry
KIN 336-3 Microscopic Anatomy (Histology)
KIN 431-3 Environmental Carcinogenesis

Description of core toxicology courses:

BISC 312 Environmental Toxicology I.

An introduction to toxicology from the biologist's perspective. The course is divided into three sections: (a) a general introduction to principles, approaches and methods in environmental toxicology, (b) an examination of specific aspects of the aerial, terrestrial and aquatic environments, and (c) general principles and methods of environmental monitoring.

BISC 313 Environmental Toxicology II

This lecture course is designed to introduce students to the field of biomedical toxicology, especially to the logical consideration of chemical toxicity. The first part of the course provides a conceptual framework which will allow students to understand the broad spectrum of toxicological problems encountered in animals and humans. The second part of the course introduces students to testing procedures used in toxicology. The third part of the course applies the conceptual knowledge of the first part in the consideration of specific problems of chemical toxicity in major target organs and biochemical systems.

BISC 432 Pesticides and the Environment

Students are introduced to major classes of pesticides according to their uses in pest control. The physical, chemical and biological properties of the chemical pesticides will be examined as well as the risks and benefits associated with their use in pest management.

BISC 650 Industrial Toxicology

A detailed examination of the major contaminants and waste products released into the environment due to industrial activities. Industrial chemicals which have harmful effects to human health and the environment also are examined.

BISC 651 Food and Drug Toxicology

An overview of drug toxicities including side-effects of drugs, drug overdose, and drug abuse. Problems related to naturally occurring food toxicants and food contaminants also are studied.

BISC 652 Problem Analysis in Environmental Toxicology

This laboratory course introduces students to testing procedures required to meet regulatory standards. In addition, there will be site visits to different toxicological testing laboratories.

BISC 846 Insecticide Chemistry and Toxicology

The aim is to provide a comprehensive review of the chemistry, toxicology, metabolism and molecular basis of insecticide action. Whilst less emphasis will be given to the older organochlorine insecticides, the factors behind their phasing out will be clearly identified. Greater weighting will be given to organophosphates, carbamates, natural product insecticides and in particular the photostable synthetic pyrethroids which have achieved widespread acceptance in agriculture and environmental health and offer a degree of selectivity that is almost unique amongst conventional insecticides.

3 Université de Montréal
Diplome en toxicologie

Domaine de concentration: Toxicologie générale

Conditions d'admission
Pour être admis à titre d'étudiant régulier le candidat doit:

a) être détenteur d'un diplôme de premier cycle en sciences biologiques, en chimie, dans l'une des disciplines des sciences de la santé, dans toute autre discipline appropriée, ou d'un diplôme jugé équivalent;
b) avoir une expérience jugée suffisante (3 ans) et pertinente dans un domaine de pratique professionnelle ou de recherche connexe à la toxicologie.

L'évaluation des qualifications du candidat est effectuée par le comité d'admission du programme. Par ailleurs, le candidat doit répondre aux exigences générales d'admission de la Faculté des études supérieures.

Un curriculum vitae complet doit accompagner toute demande d'admission.

La date limite pour soumettre une demande d'admission est le 1er mai de chaque année.

Cours requis pour diplôme

Programme
Le programme comporte 30 crédits de cours, répartis en 3 segments.

Segment 1 - Cours optionnels dans l'un ou l'autre de 3 sujets d'appoint (0 à 9 crédits)

TXL 6002 Méthodes analytiques en toxicologie
Principes des diverses méthodes analytiques applicables au domaine de la toxicologie. Études critiques des limites utiles de ces méthodes.

TXL 6004 Réponses cellulaires et tissulaires en toxicologie
Lésions cellulaires et tissulaires fondamentales rencontrées chez les principales espèces animales du groupe des vertébrés. Éléments de physiologie et de physiopathologie. Ce cours s'adresse aux étudiants provenant du secteur Chimie.

0000 N'importe quel cours de deuxième cycle en biostatistique

Segment 2 - Cours obligatoires (18 crédits)

TXL 6010 Introduction à la toxicologie
Principes généraux de toxicologie. Absorption, distribution, biotransformation et excrétion des substances étrangères. Dépistage des effets toxiques des substances sur les systèmes physiologiques.

TXL 6012 Toxicologie des médicaments
Dépistage et évaluation de la toxicité des médicaments chez l'homme et les animaux. Interactions. Réglementation pertinente au domaine.

TXL 6014 Toxicologie de l'environnement

Principes généraux de la toxicologie de l'environnement. Les effets toxiques de l'activité humaine sur la faune et la flore. Equilibre des écosystèmes. Réglementation pertinente au domaine.

TXL 6016 Toxicologie agro-alimentaire

L'utilisation des produits toxiques dans le domaine agro-alimentaire. Les effets toxiques de ces produits sur les végétaux et les animaux qui servent à la consommation humaine. La réglementation pertinente au domaine.

MSN 6018 Toxicologie industrielle

Principes généraux de la toxicologie industrielle. Monographies des principaux agents toxiques selon les sources d'exposition, la voie d'entrée, le sort métabolique et le mécanisme d'action. Mesures de contrôle biologiques de l'exposition aux agents chimiques industriels. Réglementation pertinente au domaine.

TXL 6020 Séminaire interdisciplinaire

Étude de cas sur des problèmes toxicologiques en émergence. Analyse critique de l'impact socio-économique des substances toxiques. Réflexion sur la contribution de la toxicologie à l'évaluation du rapport coût-bénéfice.

Segment 3 - Cours optionnels (3 à 12 crédits puisés dans l'un ou l'autre de 8 á 9 blocs différents)

1. Biométrie et épidémiologie
2. Ecologie et écotoxicologie
3. Morphologie normale et pathologique
4. Analyse chimique
5. Pharmacologie et toxicologie des médicaments
6. Toxicologie industrielle
7. Toxicologie agro-alimentaire
8. Aspects administratifs
9. Evaluation du risque: TXL 6030 et TXL 6031

TXL 6030 Problèmes en toxicologie: évaluation du risque toxique (I)

Préparation d'une monographie sur un agent chimique d'utilisation courante. Interprétation des épreuves de toxicité. Définition du seuil toxique et évaluation du risque toxique. Discussion critique du bien-fondé de la norme actuelle.

TXL 6031 Problèmes en toxicologie: évaluation du risque toxique (II)

Préparation d'une monographie sur un agent chimique posant problème quant à l'évaluation du risque toxique. Analyse critique des données disponibles. Discussion sur les perspectives de solution. Formulation de recommandations.

Durée de la scolarité

Les cours du programme de Diplôme sont étalés sur une période de 2 ans. Les étudiants inscrits au programme le sont à temps partiel. La durée maximale de scolarité est de 4 ans à compter de l'inscription initiale. Pour favoriser l'accès aux cours, ceux-ci se donnent en fin d'après-midi et début de soirée.

Le programme de Diplôme est placé sours la responsabilité de la Faculté des études supérieures, qui reçoit le concours de la Faculté de médecine (médecine du travail et hygiène du milieu, pharmacologie, nutrition, pathologie), de la Faculté des arts et des sciences (chimie, sciences biologiques), dc la Faculté de pharmacie et de la Faculté de médecine vétérinaire.

La gestion académique est confiée au responsable du programme, assisté d'un comité pédagogique formé de représentants de chacune des facultés et d'un représentant étudiant.

4 University of Saskatchewan
Postgraduate Diploma in Toxicology

Areas of Emphasis: General Toxicology

Admission Requirements
A recognized undergraduate degree such as an M.D., D.V.M., D.D.S., B.S.P., B.Sc., B.S.A., etc., is required. Biochemistry and physiology are prerequisites. Courses in environmental chemistry, pathology and pharmacology are desirable.

Program
Total of 30 credits, including 18-21 credits from the core courses for toxicology (See also, M.Sc. and Ph.D. programs).

Participating Colleges/Departments/Institutions
Toxicology Group, an interdisciplinary body consisting of faculty members from a number of University departments as well as scientists from other laboratories on campus.

Courses Required for Diploma
A selection from the core courses, as listed in Annex 1, but there is no thesis requirement.

DETAILS OF UNDERGRADUATE PROGRAMS IN TOXICOLOGY

1 University of Guelph
B.Sc. (Hons) Toxicology

Areas of Emphasis: Biomedical, Chemical, Nutritional, Environmental, Genetic, Mathematical.

Program

Semester 1
One biological science course from 17-115, 65-100, or 92-102.
19-100 Fundamental Chemistry I
63-108 Elements of Calculus I
76-107 Introductory Physics for the Life Sciences I
One course from English 37-109, 37-120, Philosophy 74-100, History 49-125, Psychology 80-110, Geography 45-111, Economics 36-100, Political Studies 78-130 or other humanities or social science course.

Semester 2
One biological science course from 17-115, 65-100 or 92-102
19-101 Fundamental Chemistry II
76-108 Introductory Physics for the Life Sciences II

27-150 Introduction to Programming
OR
27-170 Introduction to Computing and Information Science
OR
63-208 Elements of Calculus II, or equivalent

Elective. One course.
If a science elective is chosen, a humanities or social science elective will be required later.

Semester 3
19-179 Organic Chemistry I
19-248 Analytical Chemistry
89-204 Statistics I
94-200 Principles of Toxicology

Elective. One course.

Semester 4
15-201 Ecology
19-261 Inorganic Chemistry I
OR
19-288 Physical Chemistry

OR
19-343 Analytical Chemistry III
19-258 Introductory Biochemistry
OR
19-358 Biochemistry I
89-205 Statistics II
Elective. One course.

Semester 5
19-356 Structure and Function in Biochemistry
40-200 Introductory Genetics
71-319 Fundamentals of Nutrition
75-394 Human Physiology I
OR
77-305 Animal Physiology I
OR
92-319 Comparative Animal Physiology
Elective. One course.
* Students complete in Semester 6 the physiology sequence begun in Semester 5.

Semester 6
07-313 Biomedical Histology
OR
92-300 Comparative Histology
75-396 Human Physiology III
OR
77-325 Mammalian Physiology III
OR
92-417 Experimental Comparative Animal Physiology
19-336 Environmental Chemistry and Toxicology
Electives. Two courses.

Semester 7
Electives. Five courses.
Semester 8
94-420 Topics in Toxicology
Electives. Four courses.

Areas of Emphasis
Students in the Honors Toxicology program must select one of the following six areas of emphasis by the end of semester 4. (Students may not combine an area of emphasis and minor in a single subject; e.g., toxicology, chemical area of emphasis, plus biomedical science minor is acceptable; toxicology chemical areas of emphasis plus chemistry minor is not acceptable.)

1. Chemical Area

Counselling: Department of Chemistry and Biochemistry
Two of: (other than the course taken as part of the core program in Sem. 4)
19-261 Inorganic Chemistry I
19-288 Physical Chemistry

19-342 Analytical Chemistry II
19-343 Analytical Chemistry III

Two of:
19-452 Advanced Metabolic Biochemistry
19-454 Enzymology
19-455 Biochemistry of Macromolecules
19-458 Membrane Biochemistry
94-459 Biochemical Toxicology

Electives. Choose three courses from Preferred Electives listed below.

2. Environmental Area

Counselling: Department of Environmental Biology
15-300 Aquatic Biology
OR
92-312 Limnology and Oceanography

17-230 Plant Physiology
34-303 Pesticides in the Environment
34-453 Air Pollutants and Other Stresses on Plants
65-418 Microbial Processes in Environmental Management
72-300 Pharmacology
94-400 Medical Toxicology
One of:
71-451 Toxicological Aspects of Nutrition
72-301 Pharmacology and Toxicology
73-410 Diseases of Aquatic Animals
92-435 Limnology of Polluted Waters

3. Mathematical Area

Counselling: Department of Mathematics and Statistics (other than the one taken in the core in Sem. 2)
27-150 Introduction to Programming
OR
63-208 Elements of Calculus II

63-215 Applied Matrix Algebra
63-348 Biomathematics
63-448 Compartmental Analysis

72-300 Pharmacology
89-324 Applied Regression Analysis
94-400 Medical Toxicology

One of:
34-303 Pesticides in the Environment
63-407 Topics in Applied Mathematics I
71-451 Toxicological Aspects of Nutrition
72-301 Pharmacology and Toxicology
91-324 Epidemiology

4. Biomedical Area

Counselling: Department of Biomedical Science
34-303 Pesticides in the Environment
OR
71-451 Toxicological Aspects of Nutrition
OR
73-260 Laboratory Animal Management
72-300 Pharmacology
72-301 Pharmacology and Toxicology
73-360 Principles of Disease
91-324 Epidemiology
94-400 Medical Toxicology
94-410 Toxicological Pathology

5. Genetics Area
Counselling: Department of Molecular Biology and Genetics
65-100 General Microbiology I
40-361 Eukaryotic Cell Biology
OR
40-462 Cell Biology of the Nucleus
40-426 Environmental Mutagenesis
40-400 Cytogenetics
OR
40-305 Human Genetics
40-409 Molecular Genetics
OR
40-404 Developmental Genetics

One of:
19-452 Advanced Biochemistry I
19-454 Enzymology
19-455 Physical Biochemistry
19-458 Membrane Biochemistry
94-459 Biochemical Toxicology

Electives: three additional courses, not more than two of which may be alternate courses in the above list; the remaining electives are to be selected from Preferred Electives listed below.

6. Nutrition Area

Counselling: Department of Nutrition
40-426 Environmental Mutagenesis
OR
94-459 Biochemical Toxicology
71-332 Proteins and Lipids
71-333 Vitamins and Minerals
71-432 Nutrition and Abnormal Metabolism
71-451 Toxicological Aspects of Nutrition
72-300 Pharmacology
94-400 Medical Toxicology

Preferred Electives
Some of these courses are specified in the areas of emphasis and all are important to many areas of toxicology. Students are encouraged to include as many as possible in their course selections.

19-357 Analytical Biochemistry
34-303 Pesticides in the Environment
36-210 Economic Growth and Environmental Quality
40-426 Environmental Mutagenesis
45-321 Management of the Biophysical Environment
65-313 Food Microbiology
65-414 Soil Microbiology
71-451 Toxicological Aspects of Nutrition
72-300 Pharmacology
72-301 Pharmacology and Toxicology
78-337 Environmental Policy Formation and Administration
94-400 Medical Toxicology
94-459 Biochemical Toxicology

Description of Undergraduate Courses

94-200 Principles of Toxicology

This course will establish the scientific principles underlying the toxic actions of various substances and will introduce the various challenges within the field of toxicology. The chemical nature of injurious substances, their uptake and metabolism by non-target organisms, and their mode of toxic action will be studied in addition to the methods used in safety evaluations and risk assessment. Recommendation: students are advised to register in 89-204 concurrently if they lack statistics. Department of Biomedical Sciences. Prerequisites: Two courses in biology, two courses in chemistry, and two courses in mathematics, statistics or computing science.

94-336 Environmental Chemistry and Toxicology

The chemistry of the natural environment; the influence of pollutants upon the environment, including methods of introduction of pollutants to, and removal of pollutants from, the environment. This course is also listed under 19-336, Chemistry and Biochemistry. Credit cannot be held for both. Prerequisites: 19-101, 19-179.

94-410 Toxicological Pathology

Evaluation of the pathologic responses of cells and tissues to toxic compounds. The course is designed for students majoring in toxicology. Department of Pathology. Prerequisite: 73-360.

94-400 Medical Toxicology

The toxicology of mammalian body systems; dose-response, mechanisms and systemic sites of action of major groups of chemical toxicants. The course is designed for students majoring in toxicology. Department of Biomedical Sciences. Prerequisites: 72-300, 94-200.

94-420 Topics in Toxicology

Topics in toxicology will consist of oral presentations by students, faculty members, and guest lecturers. The emphasis will be on the broad integrative aspects of toxicology with particular reference to the whole organism and higher levels of natural systems. This course is designed for B.Sc. Honors Toxicology students in their 7th or 8th semester. Departments of Environmental Biology and Zoology. Prerequisites: 19-201, 19-336, 94-200.

94-459 Biochemical Toxicology

The molecular mechanisms of action of carcinogens and other toxic compounds. Enzymes of biotransformation, including a detailed study of cytochrome P-450. Interactions of reactive species with DNA and other macromolecules. Designed for students specializing in toxicology, chemistry, or biochemistry. Department of Chemistry and Biochemistry. Prerequisites: 19-101, 19-358, 19-359, and 40-200.

34-303 Pesticides in the Environment

The role and use of pesticides by various facets of society and the effect of these pesticides on biological activities in the environment. Prerequisite: 92-102.

71-451 Toxicological Aspects of Nutrition

The occurrence, metabolism and nutritional implications of non-nutrients, additives and environmental pollutants in foods and feeds. Influence of drugs, environmental contaminants and natural toxicants on nutritional requirements. Department of Nutritional Sciences. Prerequisite: 71-319 or 71-321.

34-453 Air Pollutants and Other Stresses on Plants

A physiological approach to the study of adverse environmental conditions on plants. Included are natural conditions causing stress, disturbances and air pollutants. Prerequisites: 15-201 or 15-203, 17-230.

40-426 Environmental Mutagenesis

DNA replication, recombination and repair. Mechanisms of mutation and relation to carcinogenesis. Methods for detection of environmental mutagens and risk assessment. Department of Molecular Biology and Genetics. Prerequisites: 40-200 and one course in biochemistry.

91-324 Epidemiology

A basic course which deals with the principles and application of epidemiology, the relationship of agent-host-environment, and vectors of disease. Department of Population Medicine. Prerequisite: Two courses in biology.

78-337 Environmental Policy Formation and Administration

This course surveys both the federal and provincial governmental policies and programs relating to the management of natural resources and the control of pollution by examining the political, legal and administrative mechanisms, monitoring surveillances, and enforcement problems.

72-300 Pharmacology

An introduction to pharmacology; pharmacokinetics, pharmacodynamics, pharmacometrics, receptor theory. Neuropharmacology: neurochemicals and drugs acting on central and peripheral nervous systems, skeletal and smooth muscle. Cardiovascular, pulmonary and renal pharmacology. Prerequisite: One course in biochemistry and one course in animal or human physiology at the university level.

72-301 Pharmacology and Toxicology

A course sequential to 72-300. Emphasis is on actions and toxicities of drugs on reproductive, endocrine and immune systems, inflammation and hypersensitivity. Carcinogenesis and cancer chemotherapy. Antimicrobial and antiparasitic chemotherapy. Prerequisite: 72-300.

73-260 Introduction to Laboratory Animal Care and Management

Significance of various animals in research, their housing, environmental requirements, handling and nutritional requirements. Animal care legislation, disease recognition and control. Prerequisite: One course in biology.

2 Université de Montréal
Certificat en toxicologie éco-industrielle

Domaine de concentration: Toxicologie industrielle et de l'environnement

Programme
(Programme comprenant 30 crédits, equivalent à 2 trimestres complets)

Requis:

MSN 3200G Introduction à la toxicologie éco-industrielle
Introduction aux notions générales de la toxicologie éco-industrielle. Les principaux phénomènes d'application pratique à l'origine de la surveillance médico-environnementale en se servant des indices d'exposition et de toxicité à partir de l'anatomo-physiologie humaine. Approche industrielle sectorielle des risques chimiques circonstanciés.

MSN 3210G Démarche toxicologique et analyse de risque
Les étapes de la démarche toxicologique: de la source à l'intervention. L'analyse de risque dans le cadre de la démarche toxicologique: l'appréciation, l'évaluation, la gestion. Préalable: MSN 3200G.

MSN 3300G Travaux dirigés
Bloc de travaux dirigés qui peuvent impliquer des visites industrielles. Ces travaux ont pour but de développer les attitudes face à un risque chimique sectoriel précis. Pour ce faire, une évaluation spécifique des connaissances et des aptitudes de l'étudiant sera réalisée par l'élaboration d'un protocole de toxicovigilance axé sur les mesures sécuritaires et sanitaires correctrices et préventives. Préalables: MSN 3200G, MSN 3210G et 6 crédits de sigle TXL.

TXL 2010 Gaz et vapeurs toxiques
La pollution urbaine, domiciliaire et industrielle comme source d'aérocontamination. Irritants primaires et secondaires. Asphyxiants simples et chimiques. Mesures de prévention et de correction. Préalables: MSN 3200G et MSN 3210G.

TXL 2020 Hydrocarbures et solvants
Principaux produits naturels ou synthétiques dérivés du pétrole. Hydrocarbures non substitués aliphatiques et aromatiques. Hydrocarbures halogénés. Alcools et cétones. Mesures de prévention et de correction. Préalables: MSN 3200G et MSN 3210G.

Deux ou trois cours parmi les suivants:

TXL 2030 Métaux
Problématique touchant la pollution industrielle et environnementale par les métaux. Métabolisme et toxicité des principaux contaminants métalliques. Mesures de prévention et de correction. Préalables: MSN 3200G et MSN 3210G.

TXL 2040 Pesticides
Classification. Toxicité des principes actifs et des véhicules. Mesures de prévention et de correction. Préalables: MSN 3200G et MSN 3210G.

TXL 2050 Dérivés aminés et nitrés

Principales utilisations industrielles. Dérivés aliphatiques et aromatiques. Mesures de prévention et de correction. Préalables: MSN 3200G et MSN 3210G.

TXL 2060 Plastiques

Classification. Procédés de synthèse industrielle. Toxicité des monomères, des polyméres et des produits de combustion. Mesures de prévention et de correction. Préalables: MSN 3200G et MSN 3210G.

Deux ou trios cours parmi les suivants:

DRT 3304G	Droit de l'environnement
MSN 2020G	Toxicologie et société
MSN 2500	Santé environnementale
MSN 2510G	Environnement et prévention
MSN 3900G	Colloques sur la toxicologie éco-industrielle Cours traitant de questions ou de problèmes toxicologiques particuliers. Préalables: MSN 3200G, MSN 3210G et 6 crédits de sigle TXL.
MSO 2000	Introduction a l'épidemiologie

3 Université du Québec à Montréal
Baccalauréat en biologie

Domaine de concentration: Physiologie et toxicologie

Programme

En choisissant l'option physiologie et toxicologie, les étudiants seront formés à l'étude des effets des polluants sur la vie végétale et animale, ceux de l'environnement de travail sur le fonctionnement de l'organisme humain, ceux des pesticides sur la vie animales, etc.

Cours à suivre

(Les cours entre parenthèses sont préalables.)

- Les huit cours suivants:

BIO1000	Méthodologie en biologie
BIO1010	Biologie cellulaire
BIO1202	Morphologie évolutive des végétaux
BIO3522	Introduction à la biostatistique
BIO3530	Microbiologie générales (BIO1010)
BIO4020	Génétique (BIO1010)
BIO6510	Biologie des polluants (BIO3060 ou BIO3300)
BIO6550	Physiologie végétale (BIO3060 ou BIO3300 ou BIO3350)

- dix-neuf cours dans l'une des options suivantes:
Physiologie et toxicologie (19 cours)

les douze cours suivants:

BIO1040	Zoologie évolutive
BIO2730	Histologie (BIO1010)
BIO3060	Biochimie I
BIO3100	Ecologie générale
BIO4130	Pharmacologie (BIO3600 ou BIO4570)
BIO4560	Biochimie II (BIO3060 ou BIO3350)
BIO4570	Zoophysiologie I (BIO2730)
BIO5570	Zoophysiologie II (BIO4570)
BIO6201	Ergophysiologie (BIO3600 ou BIO4570)
BIO6520	Toxicologie (BIO3060 ou BIO3300 ou BIO3350)
BIO6530	Toxicologie cellulaire et systémique (BIO6520)
CHI2340	Chimie organique II B (CHI1320)

un cours parmi les suivants:

BIO2070 Bioénergétique
CHI1320 Chimie organique I B

six cours parmi les suivants:

BIM2500 Sujets en sciences biologiques
BIO2200 Introduction à épidémiologie (BIO3522)
BIO3020 Embryologie (BIO1010)
BIO4040 Virologie générale (BIO3530)
BIO4530 Etude expérimentale du métabolisme microbien (BIO3530 ou BIO4020)
BIO4760 Biochimie médicale
BIO5071 Physiologie expérimentale (BIO3600 ou BIO4570)
BIO5090 Ethologie animale
BIO5120 Introduction à l'immunologie (BIO1010)
BIO5520 Régulations biologiques
BIO6031 Méthodologie biochimique
BIO6060 Biotechnologie (BIO6960)
BIO6100 Physiologie comparée des adaptions (BIO3600 ou BIO4570)
BIO6300 Santé au travail (BIO3600 ou BIO5570)
BIO6650 Biochimie de la croissance végétale
BIO6752 Initiation à la recherche I
BIO6762 Initiation à la recherche II
BIO6945 Initiation à l'analyse ergonomique (BIO1500 ou BIO6201)
BIO6960 Biologie moléculaire (BIO3060 ou BIO3350; BIO3530)
CHI1101 Chimie analytique
CHI3510 Techniques biochimiques I (CHI2300 ou CHI2340)
CHI3532 Techniques biochimiques II (CHI2340 ou CHI3510)
CHI3540 Enzymologie appliquée (BIO4560)
INF1000 Programmation de base
MIC1115 Laboratoire d'électronique générale

ou tout autre cours choisi avec l'accord de la direction du module.

Répertoire des cours de premier cycle

BIO2730 Histologie.

Etude de l'organisation fonctionnelle des tissus et organes des vertébrés. Stades précoces de l'embryogenèse. L'être pluricellulaire. Tissus primaires: épitheliums, conjonctifs (cartilage, os, sang), musculaire et nerveux. Histologie des organes: appareils circulatoire, digestif, respiratoire, excréteur, endocrinien et reproducteur; organes lymphoides, téguments. Ce cours comprend des travaux pratiques.
Préalable(s): BIO1010 Biologie cellulaire.

BIO4130 Pharmacologie

Mécanisme d'action des médicaments. Neuropharmacologie périphérique: médicaments de système nerveux autonome. Neuropharmacologie centrale: dépresseur de la sensibilité. Pharmacologie périphérique spéciale: Médicaments de muscle strié squelettique. Pharmacologie humorale, les hormones, les vitamines. Chimiothérapie.

Préalable(s): BIO3600 Physiologie animale ou BIO4570 Zoophysiologie I.

BIO6510 Biologie des polluants

Ce cours traite des causes et des conséquences de la pollution. La pollution atmosphérique; nature des polluants, sources, effets sur les organismes vivants, mécanismes d'action, niveaux permis; principaux accidents historiques, précipitations acides et relation avec la météorologie. La pollution de l'eau: nature, sources, effets, DO-DBO, traitement des eaux potables et usées, contamination de la nappe phréatique. Pollution des sols: nature, sources, persistance, phytoxicité, contamination des récoltes.

Préalable(s): BIO3060 Biochimie I ou BIO3300 Biochimie générale.

BIO6520 Toxicologie

Ce cours est une introduction à la toxicologie. Historique, nature et ampleur de la toxicologie. Evaluation de la toxicité: aspects méthodologiques et quantitatifs. Absorption, distribution et excrétion des toxiques. Biotransformation, mécanisme d'action des toxiques, interaction entre agents toxiques. Facteurs biologiques et chimiques influençant la toxicité. Principales classes d'aspects toxiques: pesticides, métaux, solvants et vapeurs, radiations, plastiques, toxines végétales ou animales. Additifs alimentaires. Ce cours comprend des travaux pratiques.

Préalable(s): BIO3060 Biochimie I ou BIO3300 Biochimie générales ou BIO3350 Biochimie.

BIO6530 Toxicologie cellulaire et systémique

Etude des mécanismes d'actions cellulaires des toxiques et leurs effets sur les principales fonctions biologiques. Cytotoxicité: lésions, réparation et adaptation. Toxicité au niveau des organes-cibles: poumons, foie, reins, système immunitaire, système nerveux.

Préalable(s): BIO6520 Toxicologie.

4 Simon Fraser University
Environmental Toxicology Minor Program

This program is designed to give undergraduates, who are working towards a degree in the sciences, an opportunity to obtain a thorough overview of the field of environmental toxicology.

Lower Division Requirements:
The following lower division courses are prerequisites in the Environmental Toxicology minor program. Most students, pursuing degree programs in science, will already have credit for most of the courses.

BISC 101-4 Introduction to Biology
102-4 Introduction to Biology
201-3 Cell Biology
CHEM 104-3 General Chemistry I for Life Sciences
105-3 General Chemistry II for Life Sciences
115-2 General Chemistry Laboratory I
118-2 General Chemistry Laboratory II for Life Sciences
251-3 Organic Chemistry I
252-3 Organic Chemistry II
256-2 Organic Chemistry Laboratory I
STAT 102-3 Introduction to Statistics, Option B
MATH 154-3 Calculus I for the Biological Sciences (or MATH 151-3)
155-3 Calculus II for the Biological Sciences (or MATH 152-3)
PHYS 101-3 General Physics I (or PHYS 120-3)
102-3 General Physics II (or PHYS 121-3)

Upper Division Requirements:
BISC 301-3 Biochemistry - Intermediary Metabolism
312-3 Environmental Toxicology I
313-3 Environmental Toxicology II
432-3 Chemical Pesticides and the Environment
plus two of:
BISC 445-3 Environmental Physiology of Animals (prerequisite is BISC 305-3)
CHEM 371-3 Chemistry of the Environment I (prerequisites are CHEM 251-3 and CHEM 261-3)
GEOG 419-4 Mass Transfer in the Biosphere

If credit for any of the above courses is already being used towards another degree or diploma, additional credits will have to be obtained from the courses listed below in order to satisfy the minimum credit requirements of 15 semester hours in upper division courses for a minor in Environmental Toxicology. None of the upper division courses listed below may be counted towards the requirements for more than one program.

BICH 301-3, 412-3, 440-3
BISC 301-3, 305-3, 366-3, 401-3, 405-3
KIN 305-3, 306-3

A grade point average of 2.0 or higher, is required for the courses in the minor program.

5 University of Western Ontario
B.Sc. (Hon.) in Pharmacology and Toxicology

Areas of Emphasis: Pharmacology and Toxicology

Requirements for Admission

Completion of the requirements for a Three Year B.Sc. in Biology with the general prerequisites for entrance into Honors Programs AND SPECIFIC ADDITIONAL PREREQUISITES:-

Program

FIRST YEAR.
The program of studies in first year must include:

Biology 020, Chemistry 020 or 023 and a suitable mathematics course. The Department of Pharmacology and Toxicology requires Mathematics 027 or 023a/b plus 033b or Applied Mathematics 020. A physics course, chosen from Physics 020, 024 or 025, is required; it would be taken usually in the first year.

SECOND YEAR.
The program of studies in second year must include:

Biology 200, Biology 201 and Chemistry 203. (Other courses, as noted below, may be included in the second year of study.)

THIRD YEAR.
The program of studies in third year must include:

Biology 300 or 301, 309 or 322a plus 338b, 310 and 362.
In addition, courses which are highly recommended by the Department include Biology 202, 209 and 311, as inclusions in the second/third year of study. These provide background appropriate for Pharmacology and Toxicology and satisfy prerequisite requirements for courses which may be taken in the Honors year.

In addition, students are advised to take Chemistry 226b, Pathology 240a, and a suitable course or half course in statistics (Biology 244a, Psychology 281 or Statistical Sciences 155b or equivalent) in their second/third year of study. If the statistics requirement has not been completed prior to the fourth year, it must be taken during the fourth year as an additional course or half course.

FOURTH YEAR.
The program of studies in fourth year is as follows:

Pharmacology 441y, 460b, 462a, 463a and 480.

At least one of: 432 a/b, 464a/b, 466a/b, 467a/b.*

To complete 5 principal courses, up to one and one half senior courses in areas of Biology or History of Science, for which the student has the appropriate prerequisite courses, selected with the approval of the Department. These include the following courses offered by the Departments of:

Biochemistry:	453a (Nucleic Acid), 454b (Protein Synthesis), 463b (Current Topics), 468a (Physical Biochemistry).
Biophysics:	467a (Radiobiology and Radioisotopes).
Chemistry:	322 (Analytical Environmental Chemistry).
Engineering Science:	363a/b (Water Pollution).
History of Medicine and Science:	440F (History of Scientific Ideas).
Microbiology and Immunology:	470a (Immunology), 462b (Advanced Virology).
Physiology:	442a (Physiology of Exercise), 461b (Cardiovascular Physiology), 462a (Reproductive and Endocrine Physiology), 463b (Posture and Movement), 466a (Body water and Physiology), 469a (Gastrointestinal Physiology), 470b (Fetal Physiology) and 471a (Physiology of Senses).

As noted, if the statistics course requirement was not completed prior to entry into the Honors year then a course or half course in statistics must be taken in addition to the above.

*Not all courses offered each year.

Description of undergraduate courses

Biology 362. General Pharmacology.

The principles of general pharmacology and a survey of the major classes of drugs. Prerequisites: Chemistry 203 or 250 or a 200 level course in Biology or Psychology with permission of the Department. 2 lecture hours. This course comprises several components covering basic mechanisms of drug action and the movements of drugs through living systems. This is followed by coverage of the interaction of drugs with major body systems such as the peripheral and central nervous systems, the cardiovascular and renal system, and the endocrine system. In addition, modes of action of antibiotics and drugs used in cancer treatment are described. Coverage is given also to drugs of abuse, such as alcohol and cocaine, and the role of drugs in society. An introduction to the study of toxicology is included.

Pharmacology 432a/b.

Basic principles of cardiovascular pharmacology with particular emphasis on cellular mechanisms of drug action and mechanisms of therapeutic efficacy in disease states. Prerequisite: Biology 310 or Biology 362 or by permission of the Department. 2 lecture hours, half course. This course examines the interaction of drugs with the cardiovascular system with particular emphasis on receptor/effector interaction and its relationship to therapeutic effects. Drug groups to be studied include adrenergic and cholinergic agents, inotropic drugs, antiarrhythmics and antianginals as well as non-steroidal anti-inflammatory drugs.

Pharmacology 441y. Seminar.

The presentation of essays on assigned topics in Pharmacology and Toxicology and participation in seminars. Prerequisites: Biology 362 or permission of the Department. Corequisite: Pharmacology 480. 2 hours, half course. This course gives students the opportunity to review a number of topics in Pharmacology and Toxicology and prepare essays and seminars on these for presentation to other students and faculty. During this process, students acquire skills in conducting searches of the biomedical literature and condensing information in an organized fashion. While the course extends through the year it carries the weight of a half course.

Pharmacology 460b. Environmental Toxicology.

Effects on man of exposure (incidental or deliberate) to industrial, agricultural and household chemicals. Preqequisite: Biology 362 or permission of the Department. 2 lecture hours, half course. Environmental toxicology is concerned primarily with the harmful effects of chemicals which are encountered by man because of their presence in the environment, with contact arising during occupational or recreational activities, or because of ingestion of water-borne biological and chemical contaminants.

Pharmacology 462a. Principles of Pharmacology.

A course which develops the role of the receptor in the production of drug response, and examines the factors that influence the presence of drugs in the body and the time course of drug action. Prerequisite: Biology 362 or permission of the Department. 2 lecture hours, half course. This course emphasizes the basic principles of the interactions between reactive biological macromolecules (receptors) and the drugs that act upon them. Included are considerations of the hypotheses postulated to explain drug responses, approaches to receptor analysis, principles of pharmacodynamics and pharmacokinetics, the biochemical pharmacology of enzymes important in drug metabolism and toxicity, and the relationships between chemical structures of selected drugs and these processes.

Pharmacology 463a. Principles of Toxicology.

The basic principles of how chemicals produce undesirable effects in biological systems. Included are aspects of absorption, distribution, biotransformation and excretion of toxic substances, their mechanisms of action and related practical concerns, such as risk evaluation and the treatment of poisoning. Prerequisite: Biology 362 or permission of the Department. 2 lecture hours, half course. This course serves as a survey, or "toxicology appreciation course". An overview is presented of the scientific background necessary for an understanding of how chemicals produce injurious effects on biological systems; basic terminology, concepts and principles of toxicology will be stressed. Initially, emphasis will be on principles most frequently involved in an understanding of toxic events induced by a large number of chemicals. In the second part of the course, emphasis will be on several important forms of chemical toxicity, such as organ, immuno-, geno- and developmental toxicity. Another objective is to point out how basic principles in toxicology can be applied, for example in safety evaluation and in the treatment of chemical poisoning.

Pharmacology 464a/b.

Pharmacology of the Autonomic Nervous System. Principles of chemical transmission of nerve impulses and mechanisms of drug effects involving modification of the activity of the autonomic nervous system. Prerequisite: Biology 310 or 362 or permission of the Department. 2 lecture hours, half course. This course exposes students to the fundamental concepts of neurotransmission within the autonomic nervous system and traces advances in knowledge from classical historic findings to our modern understanding. This course is designed to integrate knowledge of anatomy, physiological functioning, control of homeostasis, and the effects of pharmacological intervention. Problem solving projects and assignments are used to show how hypotheses can be proposed and tested. Although emphasis is placed on adrenergic and cholinergic transmission (receptor sites, sub-classification, autoregulation etc.) the importance of non-cholinergic, non-adrenergic mechanisms and co-transmission are highlighted. Examples of peripheral actions of central nervous system (CNS)-acting drugs and CNS actions of peripherally acting drugs will be discussed to demonstrate differences and similarities between the systems.

Pharmacology 466a/b.

Biochemical Basis of Neuropharmacology. A course that emphasises key neurotransmitter compounds, their formative and degrading enzymes and their functional significance. Prerequisite: Biology 300 or 301 or equivalent. 2 lecture hours, half course. This course deals with the pharmacology, physiology and biochemistry of nervous tissue with emphasis on neurotransmitter mechanisms. Where appropriate, neuroactive drugs are introduced into the subject material. Emphasis is also placed on cellular and molecular aspects of neural function and their role in the regulation of neurotransmitters, neuromodulators and other "information" substances.

Pharmacology 467a/b.

Pharmacology of the Central Nervous System. A course that examines the modes of action of the major classes of drugs that have primary effects within the central nervous system. Prerequisite: Biology 362 or permission of the Department. 2 lecture hours, half course. There are several classes of drugs which have their main effects upon the brain. These agents are used to produce desired neurological or behavioural changes or as experimental compounds to allow a better understanding of normal or abnormal brain function. The objective of this course on central nervous system pharmacology is to consider how drugs, including agents influencing memory, appetite and addictive behaviours, consciousness, biological rhythms, pain, as well as diseases affecting mental processes, are thought to work. Prior to proceeding with lectures on the above an initial series of lectures provides a background on such matters as measuring behaviour, models of psychiatric and neurological disorders, neurotransmission and neuromodulation, neurotoxins, and methods used in chemical and functional mapping of the brain.

Pharmacology 480.

Laboratory Methods in Pharmacology and Toxicology. A course of training in the techniques employed in modern pharmacological and toxicological investigation. Tutorials will supplement both lecture and laboratory work. Prerequisite: Enrollment limited and open only to students in the Honors program in Pharmacology and Toxicology. Minimum of 10 hours per week. The overall goal of this course is to provide individuals with the qualitative and quantitative methodological skills required to pursue a career in pharmacological and/or toxicological research. Students will have the opportunity to gain familiarity with a wide variety of laboratory techniques used in modern Pharmacology and Toxicology. The interaction of drugs and chemicals with biological systems will be studied using classical isolated tissue preparations, followed by laboratory exercises at the cellular, subcellular and macromolecular levels. Independent study, self-directed experimental design and effective communication of experimental results will be emphasized.

CONTACT PERSONS AND ADDRESSES

POST-GRADUATE PROGRAMS (M.Sc. AND Ph.D.)

Memorial University

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PUBLICATIONS

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CNRC-Comité associé sur les critères scientifiques concernant l'état de l'environnement

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14108	Inventory of Pollution-Relevant Research in Canada. Vols. 3, 4. Etat de recherches sur la pollution au Canada. Tomes 3, 4. 1975. 558 pp. $6.50.
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